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ACID SULPHATE SOILS AND ITS MANAGEMENT

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Introduction

Acid sulfate soils are extremely acidic soil horizons or layers resulting from the aeration of soil materials that are rich in iron sulphides, primarily pyrite (FeS_2) (van Breeman, 1982). Acid sulfate soil is any soil or sediment containing iron sulphides (principally pyrite) or products of the oxidation of sulphides (White and Melville 1996). Acid sulphate soils include all soils in which sulfuric acid may be produced, is being produced, has been produced in amounts that have a lasting effect on main soil characteristics. The extent of the acid sulphate soils are increasing with emerging problems in coastal land resources, urban development, agriculture, fisheries, mining and conservation.

Distribution of acid sulfate soil

Globally, Total area under acid sulfate soil is approximately 17 million ha

Total Asia	–	6.5 million hectare
India	–	0.4 million hectare
Africa	–	4.5 million hectare
Latin America & Caribbeans	–	2.8 million hectare
Australia	–	3 million hectare
Total world	**–**	**17.1 million hectare**

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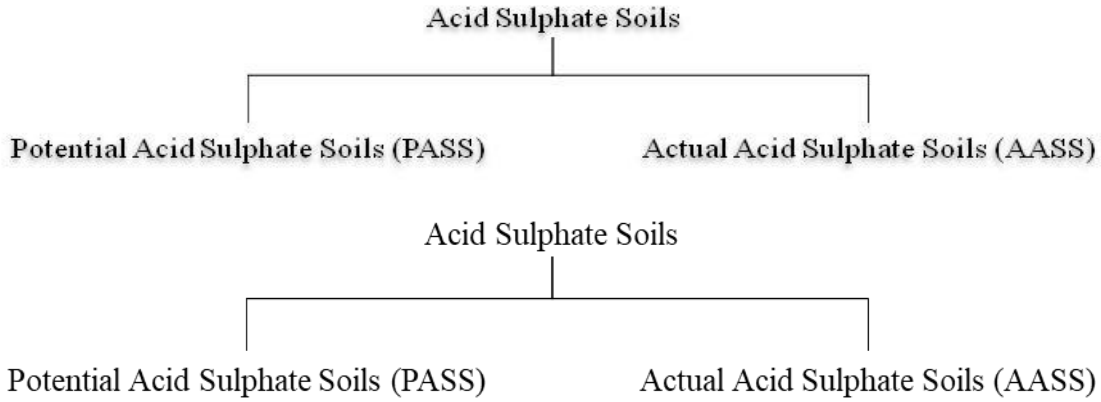
(Source: Andriesse and van Mensvoort, 2006)

In India, acid sulfate soils are mostly found in Kerala, Orissa, Andhra Pradesh, Tamil Nadu, West Bengal (Biswas and Mukharjee, 2004). In West Bengal, Sundarbans possess 40% area under Acid sulfate soil (Bandyopadhyay and Maji, 1995).



Potential acid sulfate soils (PASS) are naturally occurring soils containing iron sulfides (pyrite) with pH values near neutral. They become Actual acid sulfate soils (AASS) when they are dried and the pyrite is exposed to air and sulfuric acid is formed (Fitzpatrick, 2001).

Types	Characteristics	
PASS	➢ pH closed to neutral (6.5 – 7.5) ➢ Contain un-oxidized iron sulphides ➢ Usually soft sticky and saturated with water ➢ Usually gel-like muds but can include wet sands and gravels. ➢ Have the potential to produce acid if exposed to O_2.	
AASS	➢ field pH <4 in soils ➢ Contain oxidized iron sulfide ➢ Vary in texture ➢ Contains jarosite	

Diagnostic Characteristics

Sulfidic materials

- Oxidizable sulfur compounds
- pH > 3.5
- A drop in pH of 0.5 or more units to a pH value of 4 or less (If incubated as a layer 1 cm thick at FC at room temp for 8 Weeks)

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Sulfuric Horizon

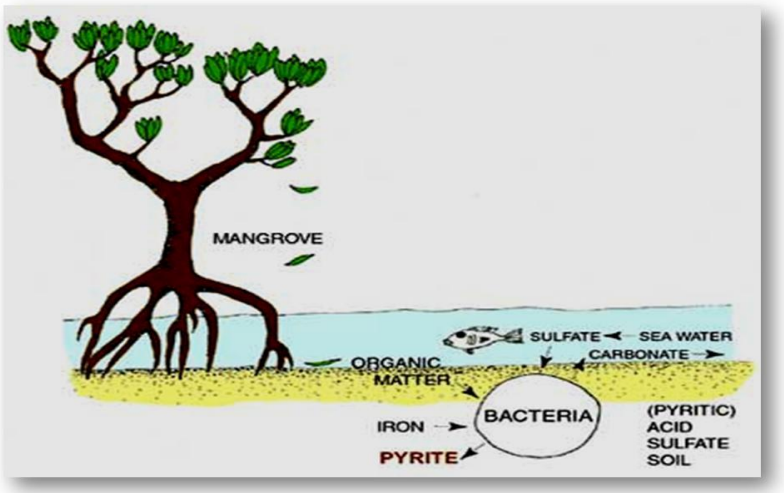
- 15 cm or more thick
- pH equal or less 3.5 due to sulfuric acid (1:1 soil: water by wt) (Keys to Soil Taxonomy, 1999)

Where do acid Sulphate soils occur ?

1. Coastal or seawater setting (below 5 m)
   -Tidal
   -Estuarine
   -Mangroves

2. Inland/ upland or fresh water setting
   -Non-tidal
   -Saline Sulphate-rich groundwater
   -Dry land salinity
   -Drains and irrigation channel
3. Mine spoil area settings
   -coal or base metals

Formation of pyrite



Source: www.qld.gov.au

Waterlogged soils – sulphate derived from sea water is reduced

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Ferrous mono-sulphide, rarely present in amounts exceeding 200 μg g^{-1} and predominantly iron pyrite, FeS_2, will be formed (Potter, 1976).

Underlying chemical reaction

$$2\ FeS_2 + 9\ O_2 + 4\ H_2O \rightarrow 8\ H^+ + 4\ SO_4 + 2\ Fe(OH)_3\ (solid)$$

↓ acidity builds up

↓ Al^{+3}, released from clay minerals under influence of the acidity

↓ alkali components immobilized

Source: Borek, 1994

Iron precipitation on concrete and jarosite [$KFe_3(SO_4)_2OH$] formation-

- Toxic amounts of dissolved iron can then be washed into waterways
- This iron precipitates when in contact with less acid water like sea water or rain water
- which results in rust colored iron oxide scum or floc which can smother vegetation and stain concrete and soil (Indraratna *et al*., 1995)

Fe (II) precipitation on drain bottom and Fe (III) floc at pH <4

(Source: Indraratna *et al*., 1995)

Reaction products

- Hydrogen sulfide (H_2S), a smelly gas; Sulfur (S), a yellow solid; Iron(II) sulfide (FeS), a black/gray/blue solid
- Haematite (Fe_2O_3), a red solid; Goethite (FeO.OH), a brown mineral; Iron compounds (e.g. jarosite)
- H-Clay (hydrogen clay, with a large fraction of adsorbed H+ ions, a stable mineral, but poor in nutrients)

A closer look to S problem

The Diagnostics

- A simple peroxide field test was carried out as a preliminary assessment of the likelihood of ASS.
- Hydrogen peroxide was used to oxidize the soil and both the immediate visual reaction and
- the change in pH from another sample of the same soil (measured in water) were recorded.

Reaction scale	Rate of reaction
X	Slight effervescence
XX	Moderate reaction
XXX	Vigorous reaction
XXXX or V	Volcanic : very vigorous reaction, gas evolution and heat generation commonly >80°C

(Source: McElnea et al, 2002a, 2002b)

Some diagnostic tools for prediction and assessment of ASS

Total oxidizable sulfur (TOS)

- A screening tool to predict the potential acidity of an un-oxidized ASS
- TOS is determined as the difference between total sulfur and HCl extractable sulfur
- Determination of total Sulfur: Soil samples were combusted in a high temperature induction furnace (LECO CNS Analyzer) in an oxygen atmosphere. The sulfur dioxide

produced was quantitatively sampled by the instrument and measured with an infrared detector

- HCl extractable sulfur is determined in a 1:40 (soil: 4M HCl) suspensions for 16 hours. Filtered aliquots were used

Modified Peroxide Oxidation, Combined Acidity & Sulfate (POCASm) method Total actual acidity (TAA)

- Acidity in the soil before oxidation with peroxide was measured by extracting samples for four hours in 1M KCl solution (1:20 soil solution ratio) and allowed to stand overnight.
- The samples were then shaken for further 30 minutes.
- An aliquot of the extract was titrated against a standard sodium hydroxide solution to determine acidity.
- A second aliquot was analyzed by ICP-AES for calcium, magnesium, sodium and sulfur (Source: Nicholas *et al.*, 2008, Angus *et al.*, 2008)

Total potential acidity (TPA)

ASS, when exposed to water and oxygen release sulfuric acid into the environment.

- Soil samples were heated to approximately 80OC in the presence of repeated additions of 30% hydrogen peroxide.
- On completion of oxidation, an aliquot of the extract was then analyzed (by titration against a standard sodium hydroxide solution) for acidity.
- A second aliquot was analyzed by ICP-AES for calcium, magnesium, sodium and sulfur

(Source: Nicholas et al., 2008, Angus et al., 2008)

Total sulfidic acidity (TSA) = TAA - TPA
Peroxide oxidizable sulfur (Spos %) = KCl extractable S without oxidation – S determined after peroxide oxidation

PASS Risk (based on the POCASm sulfur trail or TOS)

Nil or minimal risk = < 25 mol H+/tonne
Low risk = 25-200 mol H+/tonne
Medium risk = 200-400 mol H+/tonne
High risk = > 400 mol H+/tonne production.

(Source: Nicholas et al., 2008; Angus et al., 2008)

Acid sulphate soils- characterization

Properties	Observations	
Location	Surabaya, South China	Sunderbans, WB, India
pH	3 – 6.5	3.3 – 5.9
ECe	1.3 – 6.9 dS/m	0.95 – 6.25 dS/m
Organic carbon	1.5% – 18%	0.40 – 1.06 %
CEC	10 – 25 meq/100 g	18.5 – 27.2 c mol (P^+) / kg
Total sulfur	0.1 – 0.75%	High amount
Total acidity	5.2 – 18.6 c mol (P^+) / kg	2.3 – 15.4 c mol (P^+) / kg
Texture	Generally clayey	Generally clayey

(Source: Poernomo and Singh, 1982; Pal et al., 1991)

Studies in Acid Sulphate Soils – the Australian experience

Concentration in mg.L^{-1} in bore water

Parameter	Minimum Value	Maximum Value	Safe value
Aluminium	Trace	37.0	0.200
Arsenic	Trace	6.60	0.007
Iron	Trace	1200.0	0.300
Selenium	Trace	0.050	0.010
Cadmium	Trace	0.021	0.002
Chloride	73.0	257.0	250.0
Lead	Trace	0.040	0.010
Mercury	Trace	0.005	0.001
Sulphate	2.40	4047	250.0
pH	1.74	7.64	

(Source: Smith and Melville, 2004)

ASS and Agriculture

- Reduced farm productivity.
- Inhibition of root development.
- Crop suffer from water stress.
- Seed ripening arrested.
- Toxicity due to Fe^{+2}, H_2S, CO_2 & organic acid (anaerobic condition).
- Toxicity of Al, Fe, Mn, H^+ (aerobic condition).
- Reduced availability of phosphate.
- Aggressive drainage results unproductive & barren lan (Acid sulphate soils guideline series, 2009; Rebenhorst and Fanning, 2006; Pal, 1997)

ASS and Environment

- Poor water quality
- Provide predator free habitat for mosquito vector of arboviruses (River fever)
- Loss of habitat area
- Fe, Al found in toxic quantities in soil water
- Create corrosion problem in steel and concrete structures through acidification
- Acid dust during ploughing and construction activities may also cause dermatitis and eye irritation (Rebenhorst and Fanning, 2006)

Preferred management strategies

Avoidance

- Acid sulfate soils are inert when left in waterlogged, undisturbed conditions.
- Avoidance is often the most environmentally responsible and cheapest option.

Minimization of disturbance

- limiting disturbances or no disturbances are undertaken
- redesign of existing drains, shallower and wider and do not penetrate sulfide layers
- minimizing groundwater fluctuations by avoiding dewatering, deep drainage, installation of groundwater extraction bores (Sammut and Lines-Kelly, 1996; Melville and White, 2006)

Neutralization

- Neutralization of acid sulfate soils involves the physical incorporation of neutralizing/alkaline materials into the soil.
- Agricultural lime is the best choice for acid sulfate soil application.
- Thoroughly mixing the appropriate amount and type of lime into disturbed acid sulfate soils will neutralize any acid produced.
- Lime has an alkaline pH and buffers any acid produced whilst raising the soil pH to acceptable levels.
- Hydrated lime is often more appropriate for treating acid waters due to its higher solubility
- Materials that can be used include: quicklime, sodium bicarbonate, dolomite, and some industry by-products
- The amount of neutralizing agent required depends on soil and water test results and the neutralizing capacity of the lime source. (Sammut and Lines-Kelly, 1996; www.derm.qld.gov.au)

Strategic reburial

Strategic reburial involves the placement of potential acid sulfate soils into a void, where the soils can be permanently maintained in anaerobic (wet, oxygen-free) conditions at all times.

Management plans

- A good management plan will ensure that techniques to treat and manage acid sulfate soils are effective, and that adverse environmental impacts do not occur.
- Development of a thorough monitoring program is recommended as part of any management plan.
- Monitoring of soil and water should occur before, during and after disturbance to assess likely impacts (Sammut and Lines-Kelly, 1996; Melville and White, 2006).

Management Strategies

- Keeping the area flooded. Maintaining the reduced condition of flooded (anaerobic) soil inhibits acid development
- In saline mangrove swamps the recommended system is to drain the land and allow the maximum oxidation of sulphide to take place during the dry season.
- Controlling water table. If a non-acidifying layer covers the sulphuric horizon, drainage leaving the sulphuric layer anaerobic
- Liming and leaching (Sammut and Lines-Kelly, 1996)

Case study- Kerala, India

Successful application of subsurface drainage in acid sulfate soils in coastal polders of Kerala state, India (Oosterbaan, 1992)

Case study – Sundarbans, West Bengal

Approaches

1. Extensive drainage
2. Maintaining high water table

- Limiming @ 9.11 tonnes Calcium Carbonate per hectare-highest rice yield (Laskar, 1990)
- 5-6 washing and liming @ 6.0 tonnes per hectare for growing watermelon, bittergourd and rice (Mashuri, ITA 230, RD-19) (Bandyopadhyay, 1987)

Concluding Remarks

- Emerging priorities to tackle with infertilities related to acidity and other collateral constraints.
- The formation of pyrites minerals is related to the genesis of potential acid sulphate soils and oxidation of these minerals lead to formation of actual acid sulphate soils.
- Acid sulphate soils mainly occur in coastal or seawater settings, inland or upland settings and mine spoils area settings.
- ASS is very low-pH, contains toxic proportions of Fe, Al. Mn, S, reduced P, retarded crop growth
- Acid sulfate soils are virtually unproductive tract and their management for crop production is an important frontal challenge to the agriculturists
- Suitable management plans include liming, extensive drainage, minimum disturbance, strategic reburial, water table maintenance etc.

Emerging issues

- Acid sulfate soils lead to environmental, fisheries and engineering impacts and social disharmony
- The mapping of ASS and the establishment of the web-accessible National Atlas of Acid Sulfate Soils
- The establishment of planning and environmental conditions, policies and regulations that aim to minimize the disturbance of ASS
- Facilitation of research and development partnerships between research institutions and state governments to understand biogeochemical processes and assess the effectiveness of rehabilitation strategies.

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FISH FARMING IN SMALL WATER BODIES OF RAJASTHAN : BOOM OF FISH PRODUCTION

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Rajasthan is one of largest Border State of India and it sharing western and northwest borders of the country. In view of the uncertain and erratic monsoon in the state it provides maximum water for domestic uses and agricultural purposes. For the water harvesting, construct the raw ponds, cemented ponds and large water bodies and it happened since time immemorial.

The water resources in the state are 15838 in numbers of water bodies covering an area of 4,23,765 ha. The rivers and canals (30,000 ha.), water logged area (80,000 ha.) and salt affected area 1,80,000 ha. is also available. The secondary use of these water bodies is fish farming and, in the state, it is confined only to large water bodies. Despite the lack of traditional fishermen and public sentiments about fish farming, the efforts of the department of Fisheries during the last two decades the interest in the rural areas for fish farming has also started in those water bodies which are dry up every year.

On the basis of multi species rearing and appropriate farming management technology in the country, the fish production rise from 3 to 10 ton /ha/year in different water bodies. These small water bodies not only play an important role to elevate the employment opportunities in rural areas but also these are the good sources of improvement in the economic and social condition upliftment of the panchayats and economically backward families.

Selection of water body and water quality

The water body which having water spreading area at least 0.2 ha with depth remains 1 to 2 meters at least for six months is suitable for fish farming. The water quality parameters with respect to physical, chemical and biological are also important which are described in table 1.

Table 1: Water quality parameters and their optimum values for fish farming

Parameter	Optimum value
Water temperature	28-31°C
Water transparency	8-15 cm
pH	7.5-8.6
Dissolved oxygen	>5 ppm
Carbon dioxide	<4 ppm
Total alkalinity	150-300 ppm

Parameter	Optimum value
Ammonia	<0.2 ppm
Nitrate	1-3 ppm
Nitrite	<1 ppm

Preparation of water body

Water bodies in the state dry up in summer therefore, unwanted fauna and flora are not available in these water bodies. The stones, tree stumps, bushes etc. available in the pond should be removed before the arrival of the water in water bodies. The water bodies in which unwanted flora (algae, plants etc.) and fauna (fish, insects etc.) are available in the already filled ponds are need to eradicate and mechanical, biological and chemical methods should be applied to for the removal of these unwanted components. Mahua oil cake (MOC) @ 1000 kg/ha in the water body applied 20 days before the fish seed stocking or bleaching powder @ 100 kg/ha applied 7 days before seed stocking to kill the unwanted and predatory fishes.

Use of fertilizers in water bodies

The organic manure and inorganic fertilizers are used to ensure the availability of natural food in the farming pond for the fishes. These fertilizers are classified into two categories and are used as per the available nutrient content in the water of water body.

Table: List of the organic and inorganic fertilizers use for fish farming

Fertilizer	Quantity	Method of use
Organic fertilizers		
Cow dung	5 ton/ha/year	Use 50 % at the time of preparation of the water body and the rest in fortnightly installments
Chicken droppings	5 ton/ha/year	Use 50 % at the time of preparation of the water body and the rest in fortnightly installments
Gobar Gas Plant Slurry	5 ton/ha/year	Use 50 % at the time of preparation of the water body and the rest in fortnightly installments
Inorganic fertilizers		
Urea	100-200 kg/ha/year	Use in fortnightly installments
Single Super Phosphate	50-100 kg/ha/year	Use in fortnightly installments
Lime	100-300 kg/ha/year	Use in fortnightly installments

Fish seed stocking

The fish seed (fingerling) of Indian major carps and exotic carps are stocked prepared pond. The recommended stocking rate of fish seed is 50,000 fry or 10,000 fingerlings per hectare but for intensive fish farming, the seed stocking density can be increased. The seed stocking

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was done in the proportion of species (Table). The fish species catla, rohu, common carp and grass carp are appropriate for rearing in seasonal water bodies. Fish seed of fry stage (15-25 mm) should be stock as soon as sufficient amount of rain water arrives in such water bodies.

Table: List of the important cultivable fish species in the small water body

Fish Species	Contribution (%)
Indian Major Carps	
Catla catla (Catla)	20 -25
Labeo rohita (Rohu)	15 -20
Cirrhinus mrigala (Mrigal)	10 -15
Exotic Carps	
Hypophthalmichthys molitrix (Silver carp)	10 -15
Ctenopharyngodon idella (Grass carp)	5 -10
Cyprinus carpio (Common carp)	20 -25

Supplementary feed

In the natural water bodies, there is the limit to natural food for the reared fishes. Therefore, there is a need for additional food for the appropriate growth of the fish being reared. Generally, equal quantity of mustard oil cake and rice bran are use as the food source for fish. Apart from these, vitamins and mineral mixture can also be used with food ingredients. For semi-intensive and intensive culture of fish, the fishes should feed daily with 2 to 5 % of body weight of fish. It is also necessary to provide the aquatic algae in the grass carp stocked ponds.

Exchange of aqueous gases

In order to reduce the harmful gases produced by the decomposition of flora and fauna in the pond and to increase the amount of dissolved oxygen, it is necessary that the water of the water body should be reconstituted from time to time. Generally, this work can be done by the fisherman by stirring the water, but in intensive fish culture it can also be done by installing mechanical aerators.

Water exchange

The water body is polluted due to the waste produced by fishes, decomposed vegetation, unused food, manure and fertilizers. Therefore, water exchange is required to maintain the water quality of the fish pond.

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Periodic monitoring of pond

In addition to these the regular monitoring of water level, presence of algae and feeding system in fish pond is necessary to observe the growth and disease incidences. In case of illness of the pond or fish immediate need to contact the nearby fisheries department or subject specialist to get the treatment.

Duration of culture (DOC)

For the commercial fish farming, it is advisable to rear the fishes at least for 12 months. But as per the conditions of the water availability, the period of fish farming can be 6-8 months. The weight gain of the fishes during this culture duration exceeds table size (500 gm).

Harvesting and marketing

Harvesting of fish from the fish pond can be started after the fish attain table size (weighs 500 gm). As far as possible the fish are sale out in fresh condition at the pond, it is more beneficial. Small rural water bodies, which are used for various purposes, can produce fish from minimum 2500 kg to 3000 kg/ha/year at low cost by doing small scale fish culture. These rural water bodies could be a source of additional income and employment if these are allocated to the youth or weaker economic groups for fish culture.

Economics of fish farming

The economics of fish farming in one hectare water area of rural pond are described in table.

Table: Economics of fish farming in small water body

Sl. No.	Description of work	Quantity	Estimated cost (Rs.)
1.	Pond lease amount	-	5,000 /-
2.	Lime	200 Kg.	2,000 /-
3.	Mahua Oil Cake	1000 Kg.	6,000 /-
4.	**Manure / Fertilizer** 1. Cow dung 2. Urea 3. Super phosphate	 5 Ton 100 Kg. 100 Kg.	 5,000 /- 1000 /- 1000 /-
5.	Purchase of fish seed and fish transport expenses	10,000 Fingerlings	30,000 /-
6.	**Supplementary feed** Mustard oil cake, Rice bran, Fish meal, Vitamin & mineral mixture	2000 Kg.	80,000 /-
7.	**Other expenses** Medicine/ Diesel/ Electricity/ Equipment/ Labors etc.	-	20,000 /-
		Total	1,50,000 /-

Total income

1. Estimated fish production - 7,000 Kg.
2. Sale price (on pond) (Rs/-) - 50.00 Rs./ Kg
3. Total income in rupees 3000 x 100 /- - 3,50,000 /-
4. Net income in rupees 3,00,000 – 1,50,000 - 2,00,000 /- per year

Note: - The price of the fish and the recurring expenses depend on the market rate.

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RECENT OCCURRENCE OF ROOT-KNOT NEMATODES (*Meloidogyne* spp.) IN WATERMELON: A CASE STUDY

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Abstract
Root-knot nematodes, *Meloidogyne* spp., were observed as a major problem in eastern Rajasthan during the early stage of watermelon. Infested plants showed stunted growth, leaf yellowing and wilting, and widespread root gall. Two approaches of management aspect were taken into account, i.e. biological (*Paecilomyces lilacinus* and *Trichoderma viride*) and chemical (fluensulfone 2% Gr and fluopyrum 34.48% SC). Chemical control gave satisfactory results in controlling these nematodes.

Introduction
Root-knot nematodes (*Meloidogyne* spp.), sedentary endoparasites, are the most frequently observed and harmful plant-parasitic nematodes on a large number of cultivated and wild plant species. Vegetables are the most preferred hosts for root-knot nematodes infestation. The symptoms associated with root-knot nematodes can be easily diagnosed by the farmers as specific galls are present on the root system. Galls are formed as a result of physiological disturbances in root tissues due to trophic interactions of female nematodes. Above ground symptoms of root-knot nematode infested plants are yellow leaves, stunted plant growth, nutrient deficiencies, little or no fruit production and marked wilting in hot weather. Root-knot nematodes are distributed worldwide; it is more prevalent in tropical and subtropical climate regions where summers are longer than winters. Of the 14 species reported from India, *M. incognita* and *M. javanica* are the most widely distributed and attack a wide range of crops. *M. arenaria* is mostly a problem on peanut, but it does infest vegetable crops. *M. hapla* is commonly observed in temperate regions and at higher elevations in the tropics. Yield losses depend on the nematode species present, the initial population of nematodes and the crop species cultivated. The estimated crop loss is 5-43% due to the nematode infestation in the tropical agriculture, depending upon nematode species, crops and geographical regions. In India annual estimated crop loss due to major plant parasitic nematode is about Rs. 242.1 billion. *Meloidogyne* spp. may cause yield losses of up to 80% in processing tomato-growing areas, whereas *M. incognita* infection alone causes yield losses of 22–30% in tomato. In crops like brinjal, tomato, and melon, *Meloidogyne* spp. cause yield losses of over 30%. Host plant resistance and nematicides have been widely used to control nematode problem. Plant resistance is a very promising method of control, but the severe selection pressure imposed by resistant plants to many other pathogens leads to resistance breakdown. Nematicides are effective and give quick results when used on a need basis as they are highly toxic to both human health and the environment. Several alternative techniques are soil management, sanitation, organic amendments, biological control, fertilization, and heat based methods.

Recent *Meloidogyne* problem

Many farmers in eastern Rajasthan noticed signs of plant stunting, chlorosis and water stressed symptoms during the initial stage of watermelon in January 2022. Plants displayed signs of stunting or decline, usually in patches of non-uniform growth, rather than an overall decline of plants over an entire area. Most *Meloidogyne* species are easily diagnosed by farmers by the presence of root galls. But identifying a particular nematode species is difficult, and usually requires taxonomic expertise, which is not possible for farmers. Hence photographs of nematode infested plants were sent to the experts to confirm the nematode infestation (Plate 1).

Plate 1. Root-knot nematodes infesting watermelon in field.

Both above and below ground signs of nematode injury were observed. Foliar symptoms included stunting and general malaise, leaf yellowing and wilting, and signs of nutrient deficiencies. Underground symptoms involved swollen areas or galls on the roots. Symptoms of root gall can in most cases provide positive clinical confirmation of the presence of nematodes, severity of infestation and the potential for crop loss.

The time at which plant injury symptoms occur is related to the population density of the nematode, the sensitivity of the crop, and the current environmental conditions. For instance, under heavy nematode infestation, infested plants maintain a stunted condition, may fail to develop, leading to poor or patchy stand development. Under less severe condition, symptom manifestation may be delayed until later in the crop season after multiple nematode breeding cycles have been completed on the crop. In this case, above-ground symptoms will not always be readily evident during the early stages of crop growth, but with time and a decrease in the size and function of the root system, the symptoms become more pronounced and clinical.

Currently bio-control agents and nematicidal treatments were used to manage these nematodes. Nematophagous fungi, including *Paecilomyces lilacinus* and *Trichoderma viride* were applied to soil. These agents only partially controlled the nematode infestations and after non-satisfactory results, chemical nematicides were applied to the soil. These include fluensulfone 2%Gr (Nimitz) and fluopyrum 34.48% SC (Velum Prime). Nimitz belongs to a new chemical class: fluoroalkenyle, non- fumigant, systemic and highly effective against root-knot nematodes. Velum Prime is a revolutionary nematicide that provides long-lasting protection against root-knot nematodes.

Conclusion

Nematode infestations are a regular and common feature in vegetable production. In recent year, root-knot nematodes are causing major damage especially during the early stage of watermelon

and will significantly reduce yield. In the present case, nematode management can be divided into biological and chemical control measures. Neither of these control measures should be relied upon wholly for nematode management. Instead, each management practice should be used in conjunction with all other available measures for nematode control, if appropriate and economical. In addition to nematodes, many other pests can cause crop damage and yield loss imply the development of a holistic, integrated pest management (IPM) program that utilizes all available chemical and non-chemical means to reduce pest populations to sub-economic levels. An IPM program requires that growers attempt to monitor or investigate fields for pest densities at important stages of crop development.

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FARMING OF SOFT-SHELL TURTLES (*Trionyx sinensis*)

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Introduction

The soft-shell turtle (*Tryonyx sinensis*) is the most commonly raised turtle species in China and Southeast Asia (for example, Thailand, Japan, and Taiwan); there are over a thousand turtle farms in southern China alone. Because of its high reproductive capacity, widespread market recognition, and available farming expertise, this species is favoured for commercial production. Soft-shell turtles are voracious eaters, but their growth is sluggish. They can breathe naturally through their lungs underwater, but they can also absorb oxygen through their skin or by transferring water through membranes in their throat or cloaca.

Males	Females
Males are smaller	Females are normally larger, to allow for egg development
Ridge of carapace in males slightly sunken with round-shape at posterior	Shell of females rough with oval carapace
Longer neck and tail	Tail and neck is thicker
Plastron sunken	Plastron almost arched
Space between two posterior legs	Space between two posterior legs larger than male
More active	More timorous and meek than males.

Pond design

Depending on the farm's position and production capability, grow-out ponds will range in size from 100 to over 1000 m^2. The ponds range in depth from 1.0 to 1.5 metres, with a 10-20 cm thick layer of mud on the bottom.

Selection of animals for stocking

After two months, young turtles picked from the hatchling containers should be of standardized age, well, and free of pathogens. When the turtles are 10-15 g in weight, the stocking density is 10-15/m2; as the turtles get larger, the density is decreased to 5-10/ m^2 at 100-200 g and 3/ m^2 at 500 g.

Pond management

Dikes, fences, and gates are inspected on a daily basis to ensure the turtles do not flee. Turtles appear to leave the water when the turbidity is less than 30 cm, so water exchange is done once a week or when the water colour gets black. The ration is balanced according to turtle weight [200g: 7–10 percent BW/day; 200-500 g: 5-7 percent BW/day; >500 g: 3-5 percent BW/day] and fed twice a day.

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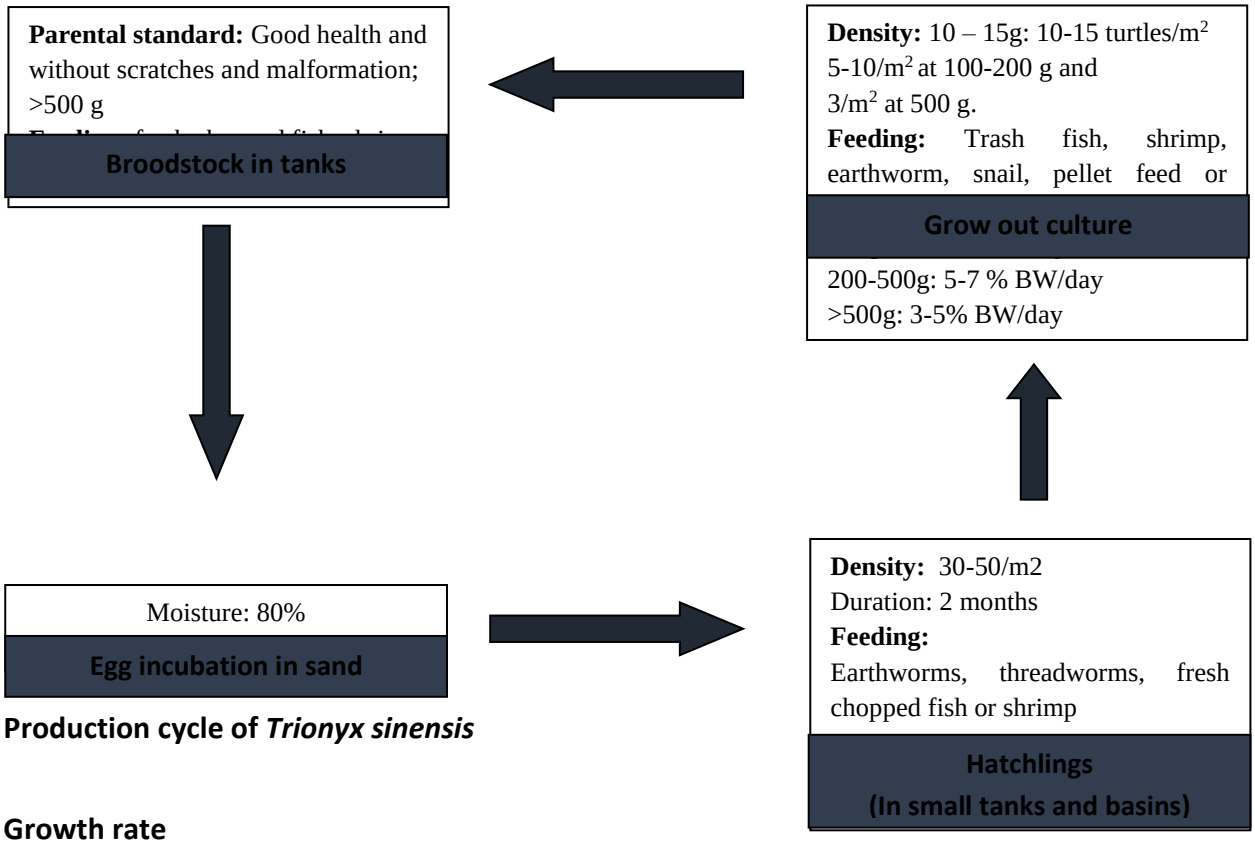

Production cycle of *Trionyx sinensis*

Growth rate

After one year in community, they weigh 400-600 g, and after two years, they weigh 1.0-1.5 kg. Their weight can exceed 1.0-1.2 kg in a single year under ideal culture conditions (low stocking density, good food, and good management).

Feed supply

Low-value fish species, shrimp, larvae, snails, pelleted or home-made feeds are used as feed (mixtures of rice bran, sweet potato, soybean meal supplemented with premix and digestive enzyme).

Harvesting techniques

The turtles attain a weight of 1.0-1.5 kg or more 12-16 months after being stocked in the rearing ponds. At this stage partial harvesting is carried out by using nets or by hand. Ponds are then completely harvested by draining and catching by hand.

Diseases and control measures

Disease	Agent	Type	Syndrome	Measures
Fungal infections	*Saprolegnia* spp.	Fungi	White patches - tufts of dirty, cotton-like material on skin & whitish areas on the shell, usually secondary	Exchange water: treat with 15-20 ppm $KMnO_4$ or 7-10 ppm $CuSO_4$ by immersion in the solution for 30 min/day, over a

Disease	Agent	Type	Syndrome	Measures
			infections	3–4day period
Septicaemic cutaneous ulcerative disease	*Citrobacter freundii* *Serratia* spp.	Bacteria	Pitted scutes & sloughing with an underlying purulent discharge; anorexia; lethargy, liver necrosis	Good hygiene; adding 20-30 mg/kg of streptomycin or penicillin to diet for 3-4 days
Necrotic stomatitis	*Pseudomonas* *Aeromonas*	Bacteria	Excessive salivation & redness of the mouth lining; cheese-like pus accumulates within the mouth; petechiae in oral cavity; ulceration or granuloma formation on mouth	3-6 mg/kg Amoxicillin or 5-10 mg/kg Enrofloxacin every 24-48 hr
Swollen neck disease	*Hydrophyla* sp. *Pseudomonas* sp.	Bacteria	Swelling of neck; closed eyelids; necrosis of feet & plastron	150-200 ppm formalin for 30-60 min; 20-30 mg/kg streptomycin or penicillin in feed for 3-4 days
Softened shell or swollen eyes	Lack of calcium & other minerals or lack of Vitamin A	Nutritional deficiencies	Deformed shells & soft bones or swollen eyes with closed eyelids	Supplemental calcium, minerals & vitamin A in turtle diets

Main issues

The main issues are the need to:

- Promote turtle farming for poor families.
- Improve farming practises and disease control.
- Provide financial assistance to farmers who want to start this form of aquaculture.

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FALL ARMYWORM ATTACKS MAIZE IN KARNATAKA

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Highlights

- Fall armyworm, *Spodoptera frugiperda* Smith is an invasive species introduced in India in 2018.
- This species feeds on a wide range of hosts but is very severe on maize, causing considerable damage in India.

Introduction

In July, 2018, framers in Karnataka saw an unknown caterpillar in their maize fields. Scientists from National Bureau of Agricultural Insect Resources (NBAIR) identified this new invasive pest as Fall Armyworm (FAW). Fall Armyworm (FAW) (*Spodoptera frugiperda* Smith) is a polyphagous pest that feeds on leaves, stems and reproductive parts of more than 350 plant species, but causing considerable damage to cereals such as maize, sorghum, rice, and also to legumes as well as vegetable crops and cotton. It is native to tropical and subtropical regions of the Americas and spread to Africa (2016), Indian subcontinent (2018), and Bangladesh, Thailand, Myanmar, China and Sri Lanka (2019). Due to its transmission capacity, it is spreading very rapidly in areas of high temperature and high humidity. In India, it has spread to about 20 states.

Life cycle

The adult female lays 100-300 white eggs on leaves. They hatch in 3-5 days. The larvae are brown in color and later turn into dark green and have four characteristic spots on the second last segment forming a square. The head has an inverted “Y” mark. They feed on leaves causing a characteristic skeletonizing or 'windowing' effect. The rate of larval development through the six instars usually takes 14-21 days. Pupation takes place inside a loose cocoon in an earthen cell and takes 9-13 days. Total life cycle is completed in 25-30 days. The forewings of adults are mottled with grey and brown. Hindwings are straw colour with a dark-brown margin.

Economic loss

In 2018, production of maize fell by 3.2% to 27.8 million tons which was 28.70 MT in 2017. It is expected that the net production will decline further due to the pest attack. If the control of this pest is delayed, it can cause huge loss to crop yield.

Control

ICAR scientists recommended the farmers to set up five pheromone traps in the infested field. Its outbreak potential can be minimized by adopting multiple cropping systems. Deep ploughing is recommended that helps in exposing pupae to predators. Timely sowing is advised. Inter-cropping of maize with suitable pulse crops reduces the pest population level in particular regions. Certain flowering plants like coriander, marigold, fennel etc. should be planted around the maize field,

which attract natural enemies of this pest. Hand picking and destruction of egg masses and neonate larvae reduce the pest population. Application of dry sand in to the whorl, balanced use of fertilizers, cultivation of maize hybrids with tight husk cover, various plant extracts such as chilli, neem, *Tephrosia*, *Tithonia*, *Lantana* and garlic are other methods of control. Emamectin benzoate is recommended to spray at the rate of 0.4 g/litre of water.

Conclusion

Fall armyworm caused a serious concern for maize farmers in India. The critical information creates awareness about this new pest among maize growers and helps in taking appropriate control measures. Farmers should get in touch with agro based organization for proper guidelines to deal with this pest.

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IMPORTANCE OF NANO-FERTILIZERS

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Agricultural land is decreasing day by day due to erosion, environmental pollution, insensible irrigation and fertilization. On the other hand, it is necessary to increase agricultural production in order to meet the needs of the developing industry as well as the nutritional needs of the growing population. In the recent years, nano fertilizers have begun to be produced to obtain the highest amount and quality of production from the unit area. Previous research shows that nano fertilizers cause an increase in the use efficiency of plant nutrients, reduce soil toxicity, minimize the potential adverse effects of excessive chemical fertilizer use and reduce fertilizer application frequency. Nano fertilizers are important in agriculture to increase crop yield and nutrient use efficiency and to reduce excessive use of chemical fertilizers. The most important properties of these fertilizers are that they contain one or more of macro and micro nutrients, they can be applied frequently in small amounts and are environmentally friendly. However, when are applied at high doses, they exhibit decreasing effects on plant growth and crop yields.

Nano-Fertilizers

Nano-fertilizers are nutrients encapsulated/coated with nano-material for the control and slow delivery of one or more nutrients in order to satisfy the nutrient requirements of plants. Nano-fertilizer is used for both materials of a physical diameter between 1 and 100 nm in at least one dimension (e.g., ZnO nanoparticles) and those existing at the bulk scale with more than 100 nm in size but that have been modified with nano scale materials (e.g., bulk fertilizer coated with nanoparticles). The exceptional properties of nanoparticles, such as high surface area/volume size ratio and enhanced physicochemical properties is now emerging as a promising strategy to promote plant growth and productivity. As a result of their unique properties, nanoparticles may influence metabolic activities of the plant and have the potential to mobilize nutrients.

Slow release : The nanocapsule slowly releases nutrients over a specified period of time.
Quick release : The nanoparticle shell breaks upon contact with a surface (such as striking a leaf).
Specific release : The shell breaks open when it encounters a specific chemical or enzyme.
Moisture release : The nanoparticle degrades and releases nutrients in the presence of water.
Heat release : The nanoparticle releases nutrients when the temperature exceeds a set point.
pH release : The nanoparticle only degrades in specified acid or alkaline conditions.
Ultrasound release : The nanoparticle is ruptured by an external ultrasound frequency.
Magnetic release : A magnetic nanoparticle ruptures when exposed to a magnetic field.

Benefits of Nano-Fertilizers over conventional chemical fertilizers

- Slow nutrient delivery systems. By taking advantage of this slow nutrient delivery, growers can increase their crop growth because of consistently long-term delivery of nutrients to plants. For example, nutrients can be released over 40–50 days in a slow release fashion rather than the 4–10 days by the conventional fertilizers

- Nanofertilizers are required in small amount which reduce the cost of transportation and field application
- Over accumulation of salt in soil can be minimized as it required in small amount
- Synthesized according to the nutrient requirements of planned crops
- The miniature size, high specific surface area and high reactivity of nanofertilizers increase the bio-availability of nutrients
- Providing balanced nutrition, nanofertilizers facilitate the crop plants to fight various biotic and abiotic stresses

Scientists believe that zinc nano-fertilizers are responsible for robust plant growth (shoot and root system) and increase the leaves chlorophyll content. In a previous study, the amendment of zinc nano-fertilizers significantly increased the yield of peanuts. These nano-fertilizers also improve seed production of vegetables. These nano-fertilizers were also found to promote the development of plant root systems in rice seedlings. Nano-fertilizers also reduce the crop cycle period and increase crop yield. For example, the amendment of nanoparticles carrying NPK (nitrogen, phosphorus, and potassium) to wheat showed an increase in grain yield and reduced the crop cycle of wheat by 40 days. Similar results were obtained in the maize cropping system. Expert opinions indicate that food products containing nanoparticles available in the market are probably safe to eat, but this is an area that needs to be more actively investigated. To address the safety concern detail studies are required to know the impact of nanoparticles within the human body once exposed through nanofood. Researchers have to assess and develop proper assessment strategies to assess the impact of nanoparticles and nanofertilizers on biotic and abiotic components of ecosystem. Among the various issues, the accumulation of nanomaterials in environment, edible part of plants might be the important issues before use in agriculture.

Drawbacks of Nano-Fertilizers

- Lack of a nano-fertilizer risk management system
- Lack of production and availability of nano fertilizers in required quantities. This limits the wider scale adoption of nano-fertilizers as a source of plant nutrients
- High cost of nano fertilizers
- Lack of standardization in the formulation process.

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ECO FRIENDLY MANAGEMENT OF BIRD PESTS OF RICE IN INDIA

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Rice (*Oryza sativa* L.) is one of the world's most important staple food crop for nearly half of the global population (Prasad *et al*., 2017). India is one of the world's largest rice producing country accounting for 20 per cent of world's production. This crop is home to nearly 1,300 species of birds (Sundar *et al*., 2010). Birds are homo-isothermous animals, belonging to Phylum Chordata and Class Aves. Birds cause quantitative and qualitative losses in the crop fields and during post-harvest operations, while drying of harvested crop/grains and open paddy storage. They not only consume the grains but also contaminate the same with their feathers, excreta etc and create nuisance and unhygienic conditions resulting in the spread of secondary infestations. Rose ringed parakeet, bank myna, rosy pastor, house sparrow, ring dove and Baya weaver damage cereals, which range from 0.1 to 6.5% in paddy (Rao and Dubey 2006). Bird foraging in rice fields is also beneficial by way of predation on harmful insects, but milky stage onwards results in grain loss by their feeding activities. The management of bird pests in India is besotted with diverse opinions and pressures raising many conservation concerns. Local, national, or international regulations and laws interfere with initiation of management of their pestiferous activities. Research and concern have resulted in several recommendations to prevent damage. However, the choice of method is riddled with controversy and is susceptible to social, economic, and political pressures. Some of the management practices like, hunting and poisoning are considered inhumane and cruel by conservationists and emerging animal rights welfare activists. To maintain a balance eco-friendly management practices are the best approach for resolving the problems with the avoidance of lethal methods as much as possible. Among many birds reported in India some of the common species known to damage paddy grains are given below:

Common myna: *Acridotheres tristis* (Linn.)
(Family: Saturnidae)

This is one of the most common birds visits the ripening fields of paddy, and feeds on the grains. This is found in all paddy growing areas of India. These birds live in pairs or in groups and also feed on the grasshoppers, fruits, earthworms *etc*. Nests are built in the vicinity of paddy fields on tree holes and breeding is from April to August with two broods in succession. Domestic duties will be shared by both the sexes for raising the young ones.

House Crow: *Corvus splendens* Vieillot
(Family: Corvidae)

This is common bird is distributed throughout the plains of Indian Subcontinent. The bird is intelligentand lookout for stealing titbits.The

house-crow no doubt is omnivorous, but also eats the ripening grains of paddy. The bird abounds in the, vicinity of towns and villages, living in close association with human beings and make nests on tree branches with a small depression in the centre for raising the young ones. The breeding season is from April to June. Domestic duties will be shared by both the sexes for raising the young ones.

Blue rock pigeon: *Colombia livia* Gmelin
(Family: Columbidae)

This bird is distributed throughout India. Visit the fields of paddy in huge flocks during grain ripening stage and in the threshing yards, they feed and also pick up the grains. Pigeons in the small flocks visit the fields after 1500 hours and remain active till the twilight. they make nests near large buildings with grass and small twigs. young ones are brought up by both the sexes. This bird breeds throughout the year.

House sparrow: *Passer domesticus* (Linn.)
(Family: Ploceidae)

These birds are common in all paddy growing areas feed on grains at sowing, ripening and also cause significant damage during post-harvest storage. They construct their nests in house roofs and medium sized trees with dried grass and feathers. House sparrows breed throughout the year.

Common Weaver Bird: *Ploceus philippinus* (Linn.)
(Family: Ploceidae)

Distributed all over India these birds cause cause considerable damage to the paddy crop during milky stage. They are known to glean paddy in harvested fields. The breeding season of the baya weavers is during the monsoons governed by its seasonal behaviour. Both males and females are polygamous. Male birds build intricately and compactly woven, retort shaped nest having a long vertical entrance tube, using paddy/palm leaves and in clusters hanging from the palm trees near ponds or water bodies.

Rose-ringed parakeet sparrow: *Psittacula krameri* (Scopoli)
(Family:Psittaeidae)

The parakeet species are common all over India and breed winter months from December to April. They nest in tree holes. Both parents care for their young ones and sharing the duties of incubation and feeding. The bird is very destructive at the ripening rice. The birds are seen in large flocks in paddy fields causing considerable damage to the crops. Parakeets feed directly from the plant.

Bird management:

- A mixture of oxygen and acetylene gas can be utilized to create loud noise at irregular intervals.
- Noisemakers: Noisemakers produce random sounds can be used to scare all birds
- Electronic device like playing tape recorded 'alarm calls' of different birds at high pitch in infested areas can also be effective
- Beating empty tins at dawn and late afternoon scaring the pigeons is very effective
- Shooting to scare, visual scares, and destruction of roosts are also some of the effective management techniques
- Practice of destroying bird nests and eggs help in reducing the bird population drastically near the vicinity of paddy fields
- Bird-tape placed over the rice plants can be one of the best options for repelling birds
- Use of flags, bird kites or scare crows, all of which move due to wind act as a deterrent to birds. However, birds get habituated to these devices quickly.
- Bird perches fixed for predatory birds in paddy field should be removed when the crop reaches milky stage
- Tying of red and yellow coloured reflective ribbons in the fields at the time of crop maturation scares the birds and prevents damage caused by them
- Dummys prepared more or less similar to man and pitched in the fields at different places or dead and stuffed crows hung from tree branches and from godown roofs preferably with spread wings can be effective for scaring away birds
- Using decoy birds is an easy and cheap method relatively for management. depending on the type of decoy bird, they can be used to repel or attract the birds in paddy fields.
- Destroying perches and denying water can also mitigate the damage
- Throwing small pieces of stones or balls made up of old cloth, jute twines/cotton waste at the birds manually or with the help of throwers also can scare birds
- Catapults can also be used to scare the birds
- Bird Boys or farm workers who *shoo away* birds can be effective if their techniques for scaring birds or catching keep changing based on type of granivorous bird species
- Godowns can be made bird proof by equipping windows, ventilators and possible entry points by putting meshes size of 0.6cm.
- To prevent entry of the birds, use of straps of cloth or polythene or bamboo or cloth or nylon curtains are quite effective.
- Exclusion netting: placing nets over paddy fields can also be effective, however, it is expensive and tends to exclude all the species of birds, even the beneficial ones. When birds get trapped within the net, it can also cause fatality
- Eco-engineering in pest control involves leaving the *bigger* bird population to hunt under natural condition without persecution. This naturally balances and manages the *system* in the rice fields. Employing large birds to scare away the small bird population is the natural food web to farmer communities' advantage.
- Reduced bird trapping or hunting for the pet trade can also restore natural balance in the paddy field.

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SMOKING OF FISH AND ITS POTENTIAL HAZARDS

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Abstract
Smoking combines the effects of salting, drying, heating, and smoking, making it one of the oldest preservation processes. Fish that has been cured by smoking is known as smoked fish. The use of fire is used in the process of smoking fish. Fish is one of the protein foods that must be handled with caution. However, roughly 40% of the fish collected is wasted owing to improper handling. To achieve a product with good quality attributes, it is necessary to understand the mechanisms involved in the smoking process in order to maximise the impact of smoke on fish products.

Introduction
Without any preservatives or processing, fish is particularly prone to deterioration and requires adequate handling and preservation to extend its shelf life, freshness, and nutritional value. Smoking is one of the oldest and most extensively utilised preservation methods. Despite its importance, the fishing industry suffers from massive postharvest losses, which are estimated to be 35-40% of total catch. These losses have a significant negative impact on fishing communities, whose livelihoods and livelihoods are frequently dependent on post-harvest activity. Smoking, on the other hand, is now primarily employed to get the appropriate colour, flavour, aroma, and appearance in smoked food rather than for preservation. Humans have known about smoking as a method of preparing fish and meat since the Stone Age. Smoking is a collection of chemical, thermal, diffusive, and metabolic activities that occur in a salted product before it is smoked. Today, the technology is used to treat 15% of all fish in a variety of ways. Smoking is a method of introducing flavour, taste, and preservation compounds into fish by exposing it to smoke from smouldering wood or plant materials. In a smoking chamber, this procedure is usually characterised by an integrated combination of salting, drying, heating, and smoking processes. Smoke not only provides food a unique flavour, colour, and scent, but it also helps to preserve it due to its drying, antibacterial, and antioxidant characteristics. Smoked fish is a ready-to-eat product that is in high demand in sophisticated Western markets. Smoking is also employed in the preservation of canned smoked fish as a phase in the process. Fish is smoked before canning to give it a smoky flavour.

Types of smoking
Depending upon the source of smoke and smoking temperature there are four types of smoking process:

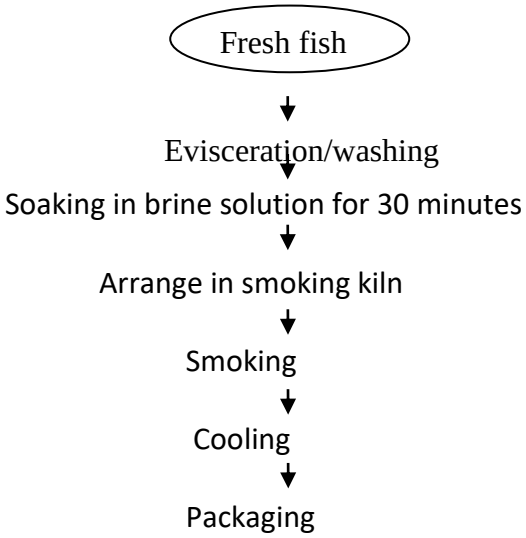
1) **Hot smoking:** It's the old-fashioned way of smoking, which takes place at temperatures above 70°C. The fish is thoroughly cooked during hot smoking, and the client can eat it without further preparation. Traditional smoking methods employing both smoke and modern smokers/smokehouses can be used to achieve a hot smoking process. Because it allows for

perfect control of the heating temperature, air ventilation, and smoke density, the Torry smoking kiln is regarded as a model for current smokers/smokehouses. In most cases, hot smoking is not a single procedure. Other procedures, such as brining, curing, and smoking, are also required to achieve a high-quality product.

2) **Cold smoking:** The temperature is normally kept below 30°C for cold smoking. The fish will not be cooked here, and it will simply be utilised to flavour the fish meat. As a result, it must be cooked before eating and is usually severely salted. Because the temperature in temperate nations is very low, this method is used. Cold smoking, as opposed to standard hot smoking, takes longer, yields more, and keeps the original textural features considerably better than hot smoking. Cold smoking of a variety of fish species, including rainbow trout, has been documented.
3) **Liquid smoking:** Smoke condensate that has been dissolved in a solvent, such as water or oil, is known as liquid smoke. Liquid smoke can be sprayed or dipped directly on goods. Traditional cold and hot smoking procedures take longer and are more difficult to generate a consistent smoke flavour. Other benefits of liquid smoke include ease of customization, application to foods that are traditionally not smoked, lower operating costs, and lower pollution levels.
4) **Electrostatic smoking:** Smoked particles are charged into an electrical field (typically positively charged) while fish are negatively charged at the same time. The fish clings to the positively charged smoke particles. It's a quick procedure. Smoking's efficiency is still higher than that of traditional smoking. The thickness of the skin, the presence of scales, and the amount of subcutaneous fat can all affect the electrostatic smoking process.
5) **Major steps involved in smoking process of fish**
    1. **Brining:** Cleaned fish are soaked in a brine solution for a specified period of time after being pre-processed. Brining the fish for fewer than 12 hours at 3.3 °C is advised to reduce the risk of spoiling. As a preventative strategy against spoiling, salt is a vital element to be introduced into the fish tissue at this time. It not only enhances the flavour, but it also lowers the water activity (aw) in the product, preventing bacterial growth in the smoked salmon. After brining, the fish must be rinsed with clean water to remove the brine solution from its surface, as brine solution residues can cause a harsh, salty flavour.
    2. **Drying:** After being pre-processed, cleaned fish are soaked in a brine solution for a specific amount of time. Brining the fish for less than 12 hours at 3.3 degrees Celsius (38 degrees Fahrenheit) is recommended to reduce the risk of spoilage. Salt is an important element to put into the fish tissue at this stage as a prophylactic measure against spoilage. It not only improves the flavour of the smoked salmon, but it also lowers the water activity (aw) of the product, inhibiting bacterial growth. The fish must be rinsed with clean water after brining to eliminate the brine solution from its surface, as brine solution residues can give the fish a harsh, salty flavour.
    3. **Smoking:** Smoke is produced when wood is burned incompletely at particular temperatures, followed by the thermal decomposition or pyrolysis of high molecular organic molecules into volatile lower molecular mass organic chemicals. Several factors influence the quality and composition of smoke, including combustion temperature, wood type, moisture content of wood, air ventilation rate, and wood size. The three primary components of wood are cellulose, hemicellulose, and lignin, and their contents and compositions fluctuate depending on the type of wood.

4. **Packaging:** After smoke drying, fish should be cooled to at least room temperature, preferably to around 0°C, before packing. Otherwise, mould will easily form on them warm, resulting in a shorter shelf life. Fish that are to be vacuum packed are an exception; if they are taken from a chill room and packed, condensation may form inside the pack, and the resulting ice crystals may give the impression that the pack has been thawed and refrozen at some point. At room temperature, place the fish in vacuum packs. The fish are packed in branded clear cellophane or polythene bags to keep dust and bacteria out.
5. **Storage:** White fish hot smoked items last longer than fatty fish hot smoked products, while shelf life varies greatly depending on the amount of salt and smoke used, the degree of drying, and the storage temperature. Fatty items will stay in good condition for about 6 days at a chill temperature of about 3°C, and white fish products will maintain in good condition for about 8 days; above 10°C, the shelf life is reduced to 2-3 days for fatty fish and 4-5 days for white fish. Hot smoked items can be frozen and kept for at least 6 months in a cold store at -30°C, and even longer if vacuum packed.

Flow chart showing smoking processing of fish



Hazards associated with smoking of fish

Biological hazards: Cold smoking is done at a temperature of 22-28 degrees Celsius. This temperature, however, is insufficient to eradicate the risk of *Listeria monocytogens*, a gram-positive, facultatively anaerobic that causes septicaemia, meningitis, and foetal death in adults. Because of inappropriate handling and storage, hot smoked products are prone to post-process contamination from a variety of microorganisms. Biological dangers in smoked fish and fisheries products can be reduced with proper heat treatment, hygienic handling, and cold chain maintenance during distribution.

Chemical hazard: Polycyclic Aromatic Hydrocarbons (PAHs) are a wide group of chemical compounds that comprise two or more fused aromatic rings made up of carbon and hydrogen atoms. During smoking, incomplete combustion (pyrolysis) can result in the creation and release of PAHs into the smoked product. Some of them, such as benzopyrene and benzoperylene, are carcinogenic and mutagenic, putting consumers' health at risk.

Physical hazards: Physical risks can include parasites such as nematodes, cestodes, and trematodes, as well as any other foreign matter. If a parasite risk exists, pay special attention to cold smoked or smoke-flavored products, which should be refrigerated before or after smoking if a parasite risk exists.

Other potential hazards associated with smoking of fish

If natural toxins or impregnating material are present in the wood or plant material used for smoking fish, it is possible that these materials impart a disagreeable odour to processed products. This can be avoided by utilising sufficiently dried wood or plant material for smoke generation, prudent species selection, and avoiding the use of woods with mould or fungus growth in the smoking process. Furthermore, the smoking material should be stored in a clean, dry environment until it is used to avoid contamination.

Conclusion

Even though smoked fish is widely enjoyed, according to the research, one of the main issues linked with smoked fish is the presence of PAHs and their link to cancer. The mechanical way of smoking is significantly safer than the traditional method of smoking since it uses a solid or liquid type of smoke. The smoke flow in the mechanical kiln is computer controlled, and the fish are smoked for a shorter period of time than in a traditional kiln. This reduces the amount of PAHs deposited on the surface of the fish as well as the amount of these carcinogens consumed by consumers. Because the majority of PAHs deposited on fish are located near the surface, adequate process control and prevention of smoked fish are essential.

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ADVANCES IN SUGARCANE PRODUCTION

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Abstract
Sugarcane (Saccharum sp. hybrids) is a highly productive C_4 grass used as the main source of sugar and more recently to produce ethanol, a renewable transportation fuel. Many improved technologies and practices has been developed for scientific sugarcane cultivation like- Improved planting methods for low labour requirement, High yield, high B:C ratio and high multiplication rate. Improved varieties for high cane yield, higher sugar recovery, and for biotic and abiotic stress management. Mechanization of sugarcane cultivation to reduce cost of cultivation by saving labour cost, and timely finishing farm practices eg. planting, weeding, and harvesting.Integrated nutrient management , Integrated weed management, Intercropping systems which having high land equivalent ratio, Tissue culture technique.There is increased interest in this crop due to the impending need to decrease the dependency on fossil fuels. Tissue culture and transgenic approaches aiming at incorporation of herbicide resistance, abiotic and biotic stress tolerance, metabolic engineering and production of value added products in sugarcane will be discussed.

Key words : Mechanization, Source of sugar, Ethanol, integrated weed management.

Introduction

Sugarcane (*Saccharum spp.*) is a C_4 plant and one of the most efficient photo synthesizer in plant kingdom. Sugarcane (Saccharum sp. hybrids) is a highly polyploid and frequently aneuploid, interspecific hybrid (Sreenivasan*et al*., 1987). Sugarcane is a tropical, perennial grass that forms lateral shoots at the base to produce multiple stems. The stems grow into cane stalk, which when mature constitutes approximately 75 per cent biomass of the entire plant.It is the main source of sugar in India and holds a prominent position as a cash crop in Indian agricultural scenario on account of its wider adaption under varying agro-climatic conditions in the country.

1.1 Sugar production : India is the world largest sugar producer in the world. In 2018 India produced about 34.3 Mt. sugar.

1.2 Sugarcane production-

Sugarcane is the world's largest crop by production quantity, with 1.8 billion tonnes produced in 2019, with Brazil accounting for 40% of the world total. In 2012, the Food and Agriculture Organization estimated it was cultivated on about 26 million hectares (64 million acres), in more than 90 countries.

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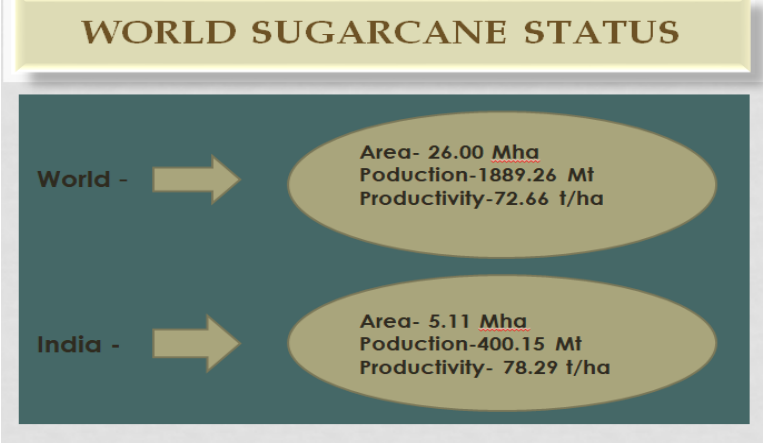

Fig: 1 sugarcane production in India and world.

1.3 Major Constraints in Sugarcane Production

- Non-availability of quality seed
- Low germination percentage
- High weed infestation
- High disease incidence
- Non-synchronized tillering
- Low irrigation water availability
- Lack of suitable varieties
- Long duration of crop
- Uneconomic ratoon crop
- Constraints in sugarcane mechanization
- Financial and managerial constraints

2. Planting techniques

- Trench Method or Java method
- Ring and pit method
- Sabling or Sprouting Method
- Tjeblock Method
- Bud Transplanting
- Algin Method of Sugarcane Planting

3. Integrated weed management in sugarcane ratoon crop

4. Intercropping in sugarcane

5. Mechanization in sugarcane cultivation

6. In Vitro Culture for Sugarcane Improvement

7. Biofertilizers

- These are living organisms which augment plant nutrient supply in one way or the other
- The use of bio-fertilizers is currently gaining interest as a cheap, safe alternate to conventional chemical fertilizers
- Bio-fertilizers are available for full filling the requirement of all major (NPK) and some minor (Zn, S) nutrients

7.1 Nitrogen fixing biofertilizers:

7.2 Phosphorus solubilising biofertilizer:

8. Sustainable sugarcane initiative-

- Sustainable Sugarcane Initiative is a method of production using less seeds, less water and optimum utilization of fertilizers and land to achieve more yields.

9. Bio-control agents

- The bio control agent used Trichogrammachilonis, an egg parasite to control Inter node bore and many lepidopteran pests

10. **Drip fertigation**

Objectives-

- ➢ Maximize profit by applying the right amount of water and fertilize
- ➢ Minimize adverse environmental effects by reducing leaching of fertilizers and other chemicals

Advantages-

- Relatively uniform fertilizer applications
- Flexibility in timing of applications
- Less fertilizer used
- Reduced cost

11. Cane advisor -A digital compendium on sugarcane-

What is Cane Adviser-

- Cane Adviser is a computer program designed to run on mobile devices to know about scientific sugarcane cultivation.

Importance of Mobile App-

- M-app is application software has many key advantages like affordability, wide ownership, voice communications, and instant and convenient service delivery.

Sugarcane ethanol-

- Sugarcane ethanol is an alcohol-based fuel, produced by the fermentation of sugarcane juice and molasses.
- Because it is a clean, affordable and low-carbon biofuel, sugarcane ethanol has emerged as a leading renewable fuel

❑ Ethanol can be used two ways:

1. 1. Blended with gasoline at levels ranging from 5 to 27.5 percent to reduce petroleum use, boost octane ratings and cut tailpipe emissions
2. 2. Pure ethanol – a fuel made up of 85 to 100 percent ethanol depending on country specifications – can be used in specially designed engines

❑ Benefits

✓ Reduced Greenhouse Gas Emission

✓ Better Performance (Ethanol is a high-octane fuel)

Lower Petroleum Usage

Conclusion- Used this all Parameters for better productivity-

S.NO.	Parameters	Advances
1	Planting material	2 Budded setts, 3 Budded setts
2	Improved varieties	Co 98014, Co 0118, CoH 64, CoH 99
3	Planting method	Ring-pit method, Bud chip planter
4	Crop diversification	Intercropping (Pea, potato, wheat)
5	Weed management	Integrated weed management
6	Fertilizer management	Fertigation
7	Mechanization	Sugarcane cutter cum planter, Mechanical planter
8	Bio-fertilizer	*Azospirillum, Azotobacter*
9	Irrigation management	Drip irrigation
10	Insect management	Bio control agents (*Trichogramma chilonis*)
11	By product	Ethanol production
12	Digital app	Cane Adviser

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AQUAPONICS: SUSTAINABLE APPROACH IN AQUACULTURE AND AGRICULTURE

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Abstract
Aquaponics, a variety of fish farming and soilless plant cultivation, is increasing popularity and awareness as an essential and potentially more sustainable technique of food production. The Aquaponics system is aided as a model for a natural aquatic environment. Because of the synergetic uptake and release of effluent from fish to plants, the Aquaponics system must be monitored regularly. It is also a sustainable food-producing source in sustainable agriculture.

Keywords: Fish, Aquaponics, Hydroponics, Sustainable

Introduction

Aquaponics, or the combination of hydroponics and aquaculture, is gaining popularity as a bio-integrated food production method. Aquaponics is a growing subject of study in the field of sustainable food production. The multi-trophic food production technologies of recirculating aquaculture systems (RAS), as well as hydroponics, are combined in decoupled multi-loop aquaponics (Goddek *et al*., 2016). Aquaponics is the mutually advantageous combination of hydroponics (e.g., soilless crop production systems) and aquaculture (e.g., aquatic animal husbandry) to generate plant and animal goods at the same time. Aquatic creatures produce waste in an aquaponic system, bacteria turn the waste into nutrients, and plants take the nutrients and enhance water quality for the aquatic animals.

Principles of Aquaponics

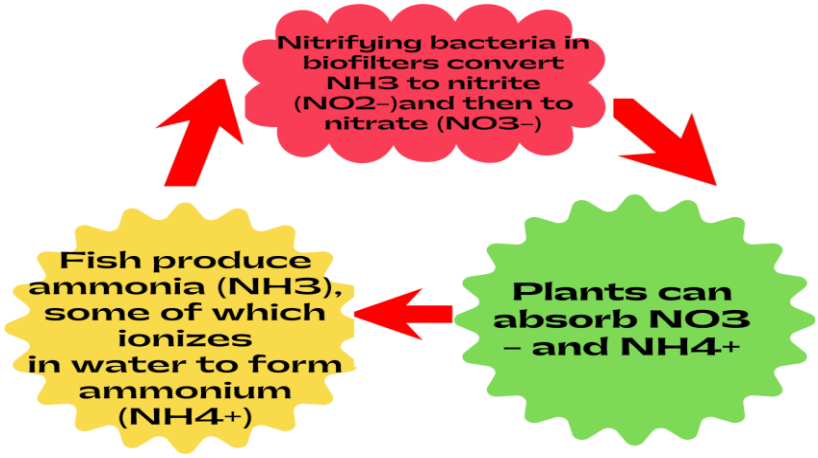
Aquaponics is a model of sustainable food production that adheres to the following principles: The waste products of one biological system are used as nutrients by another. The combination of fish and plants produces a polyculture, which enhances diversity and yields a variety of products. Through biological filtration and recirculation, water is reused. Local food production increases access to healthful foods while also benefiting the local economy.

Major components of Aquaponics

The system is made up of three fundamental elements: fish cultivation, solid withdrawal, and hydroponic plant cultivation for biofiltration.

Nutrient re-cycling

Aquaponics reuses water and nutrients that would otherwise be dumped into the environment, potentially polluting it. To achieve optimum water quality, aquaponics systems balance nutrient production from fish waste with nutrient uptake by plants.



Types of aquaponics systems

Aquaponics systems are classified into three types: grow bed methods, also known as particle beds, deep water culture (DWC) methods, also known as the raft method or floating systems, and nutrient film techniques (NFT) methods.

Fish species in an aquaponics system

The reasonable fish for aquaponic systems are adjusted by the size of the system, its location and temperature, and the type of crops it will generate. Top selections include tilapia, catfish, goldfish, tetras, bass, cod, salmon, perch, trout, and sunfish.

Plant in an aquaponics system

Most of the plants that require more amount of nutrients will only grow in a well-stocked, well-established aquaponic system. In aquaponics, aquaculture systems grow a variety of vegetables such as leafy lettuce, carrots, cauliflower, cabbage, tomatoes, peppers, cucumbers, brinjal, beans, coriander, as well as other herbs and vegetables.

Application of aquaponics

Aquaponic systems are available at a wide range of scales and for a variety of purposes, including personal use or as a hobby, community as well as income generation (Goodman, 2011), science education (Wardlow *et al*. 2002), and higher food production in urban settings where possibilities for traditional crop production are restricted due to environmental contamination and space constraints (Metcalf and Widener, 2011).

Conclusion

Aquaponics systems are available at a wide range of scale sand for a variety of purposes. Aquaponics is a growing subject of study in the field of sustainable food production. It is a sustainable food-producing source in aquaculture as well as agriculture.

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NEWSPAPER: PROVIDING INFORMATION TO RURAL COMMUNITIES

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Newspaper is a form of print media. It is an influential approach of mass communication. Newspaper published in many different languages. In newspaper, every type of news is available like, agriculture, rural development, women empowerment, capacity building, sports, business, politics etc. Newspaper is a supreme house of information. It makes the general public aware about what's going on around the World. A newspaper is a periodical publication which is usually issued on daily or weekly basis. It contains news, articles of opinion, features, advertisements and other information of public interests. According to Registrar of Newspaper for India (2018) there were over 100,000 publications registered. India has the second-largest newspaper market in the World, with daily newspapers reporting a combined circulation of over 240 million copies as of 2018. We are living in the age of Information Communication Technologies. The public media as Radio, Television and press are knocking twenty four hours. The relaxed, inexpensive and rapid means of communication have brought the unfriendly corners of the world closer. The newspaper is the main structure of communication. It contains both news and views on matters of public and National importance. Newspapers are very important in developing society. Newspaper has great influence on Nation. Newspaper provides the space to reviewers to write their point of views also. Newspaper provides the information, education to the readers.

Newspaper has always enjoyed the position of most liked medium to reach a large number of people until the electronic media emerged as a tough competitor but still, newspapers have maintained their great stake in India. Newspaper is a very important medium of development communication. Even during the times of independence, it was the print media i.e. newspapers that played a vital role to spread information about five-year plans to the masses. Various development programs were down lined to the general public in their interests. It covered various subjects relating to weather, market ups and downs, seeds, marketing, implements, and many other things. Scientific and technological advancements have also boosted all of these.

Newspapers have got a huge control in the grass root levels of the country as they have a great responsibility in providing relevant information timely.

Table 1: Newspapers in India

No	Newspaper	Language	Headquarters	Total circulation till June-Dec(2019)
1	Dainik Bhaskar	Hindi	Bhopal	4,579,051
2	Dainik Jagran	Hindi	Kanpur	3,614,162
3	The Times of India	English	Mumbai	2,880,144
4	Malayala Manorama	Malayalam	Kottayam	2,308,612

No	Newspaper	Language	Headquarters	Total circulation till June-Dec(2019)
5	Amar Ujala	Hindi	Noida	2,261,990
6	Hindustan Dainik	Hindi	New Delhi	2,221,566
7	Rajasthan Patrika	Hindi	Rajasthan	1,788,420
8	Eenadu	Telugu	Hyderabad	1,614,105
9	Dina Thanthi	Tamil	Chennai	1,472,948
10	The Hindu	English	Chennai	1,415,792
11	Sakal	Marathi	Pune	1,263,955
12	Mathrubhumi	Malayalam	Kozhikode	1,230,778
13	Punjab Kesari	Hindi	Jalandhar	1,105,851
14	Patrika	Hindi	Jaipur	1,095,144
15	Hindustan Times	English	New Delhi	1,072,966
16	Sakshi	Telugu	Hyderabad	1,064,661
17	Ananda Bazar Patrika	Bengali	Kolkata	1,046,607
18	DivyaBhaskar	Gujarati	Ahmedabad	792,022
19	Dinamalar	Tamil	Chennai	768,300
20	Vijayavani	Kannada	Hubli	757,119
21	Vijay Karnataka	Kannada	Bangalore	673,639
22	Pudhari	Marathi	Kolhapur	669,998
23	Andhra Jyothi	Telugu	Hyderabad	664,352
24	Bartaman	Bengali	Kolkata	635,296
25	Deshabhimani	Malayalam	Trivandrum	568,039
26	Prajavani	Kannada	Bengaluru	478,374
27	The Economic Times	English	Mumbai	359,142
28	The Telegraph	English	Kolkata	352,972
29	Udayavani	Kannada	Manipal	278,236
30	EiSamaySangbadpatra	Bengali	Kolkata	243,27

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Role of mass media in development

"Media" is plural form of medium which refers to the communication channel or by which something is done i.e., it means mode of expression. Thus media refers to sources of communication like print, radio, television, social, etc. Media is considered as a very powerful tool of Indian democracy, it is considered as the fourth pillar of democracy. Generally, media can be broadly classified into two main categories, print media, and electronic media. Print media includes magazines, newspapers, booklets, books, newsletters, etc., and electronic media includes radio, television, and films.

Everywhere and everyday something or the other happens. Information needs to be communicated from one place to the other. This role is solely dependent on mass media. These guide, entertain, and educate people around the world. Media influence the way people look at different things and helps them to make an opinion and organize them. Millions of people read

newspapers, magazines, watch television, or are engaged with social media. This mass media has become an indispensable part of human life which is impossible to resist. Mass media have been designed to reach a large number of audiences for various purposes like business, social concerns, current affairs, etc.

Media is specially designed to reach a large number of audiences. Thus, it is often known as “mass media”. Mass media, from its name only it can be said it’s a media that reaches to the mass that has been spread over a large area. So any media that multiply messages and take it to a large population simultaneously is known as ‘mass media’.

Conclusion

Newspaper play a very important role in disseminating information among the rural community. Local newspaper provides the information in local language. Generally local people want to read the information in local language. Thus, we can say that information dissemination is very important and media play a very pivotal role in disseminating the information.

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BIODIVERSITY AS VITALITY IN THE NATURAL ENVIRONMENT

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Highlights

- Biodiversity is the variability among living organisms on Earth.
- Biodiversity plays an important role in nature such as biomass production, nutrient and water cycling, soil formation, invasion resistance, pollination, climate regulation, and pests, diseases and pollution control.

Introduction

The term biodiversity (biological diversity) was given by Edward Wilson and it refers to the variety of life at all its levels (from genes to ecosystems) on earth. Biodiversity forms the foundation for a vast array of ecosystem services that contribute significantly to human well-being. It represents the collective intelligence learned by species that have evolved over millions of years on how to survive in widely changing environmental conditions on earth. It includes all ecosystems, managed or unmanaged. The International Day for Biological Diversity (22 May) together with World Environment Day (5 June), World Bee Day (20 May) and World Day for Cultural Diversity for Dialogue and Development (21 May) is devoted to increase understanding and awareness of biodiversity issues. Biodiversity plays a significant role in maintaining ecological balance, high productivity and human health, and genetic resource for humankind. Biodiversity is valued for many reasons such as some utilitarian and some intrinsic. Utilitarian values include many of the basic needs of human beings such as food, fuel, shelter and medicines. In addition, ecosystems provide important services like nutrient cycling, pollination, water purification, seed dispersal, climate regulation and control of agricultural pests. Biodiversity also has cultural value for humans for spiritual or religious reasons, and holds value for potential benefits that have not yet been recognized, such as new medicines and other potentially unknown services. The intrinsic value refers to inherent value of biodiversity, which is independent of its value to anyone else. The value of biodiversity can also be understood through the prism of relationships we form and endeavor with each other and with the rest of nature. Keeping in view the above facts, the study of the role of biodiversity in the natural environment is very important.

Role of biodiversity

Biodiversity has a central role in ecosystem functions, providing many supporting and regulating services.

Supporting services

Biodiversity influences key ecosystem processes in terrestrial ecosystems such as nutrient and water cycling, biomass production and soil formation and retention that control and ensure supporting services with high certainty. The relationship between supporting ecosystem services

and biodiversity depends on relative abundance, composition, functional diversity and to a lesser extent taxonomic diversity.

Regulating services

Invasion resistance

Conserving the number, type and relative abundance of resident species can enhance invasion resistance with moderate certainty in a wide range of natural and semi-natural ecosystems. Although areas with high species richness (hot spots) are more vulnerable to invasion than species-poor areas, conservation of its natural species pool within a given habitat appears to increase resistance to invasion by non-native species.

Pollination

Pollination is essential for the provision of plant-derived ecosystem services, yet pollinator diversity has declined worldwide with moderate certainty. Many vegetables and fruits have need of pollinators; hence pollination services are important for the production of a large proportion of the vitamins and minerals in the human diet.

Climate regulation

Biodiversity affects climate at local, regional and global levels, therefore changes in land use and land cover that influence biodiversity can influence climate. Plant functional diversity and the type and distribution of habitats in landscapes are the important components of biodiversity. These affect the capacity of terrestrial ecosystems to confiscate carbon, albedo (proportion of the sun light reflected back into space by the land surface), temperature, evapo-transpiration, and fire regime, which affect climate at the landscape, ecosystem, or biome levels.

Pest, disease, and pollution control

The maintenance of natural pest control that benefits rural household income, food security, and the national income of many countries is heavily dependent on biodiversity. The production of desired products from agro-ecosystems may be reduced due to above and below ground attacks of herbivores and microbial pathogens and by competition with weeds. However, increase in biodiversity with low-diversity agricultural ecosystems can enhance biological control of pests and reduce the dependency and costs associated with the use of biocides. Furthermore, highly diversified agricultural system has cultural and aesthetic value and can decrease many of the externalized costs of irrigation, pesticide and fertilizer inputs associated with monoculture agriculture.

Conclusion

This essay reveals the concept of biodiversity and its importance for all living organisms of the ecosystem, including humankind. Today's biodiversity is the result of billions of years of evolution, created by natural processes, performing many ecological services. The present need is, therefore, to focus on the conservation of all species, even if they are ecologically equivalent species.

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INTEGRATED AQUACULTURE: A BETTER WAY TO UTILIZE AVAILABLE RESOURCES

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Introduction

Nowadays, food scarcity is one of the biggest problem faced by the human population. For that we should be mainly focused on the reduced unit cost of production by efficient use of resources, increasing production and profitability and improving quality and quantity of food. Integrated aquaculture refers to the production of fish, agriculture, and animal-based food products. Fish is the major production in integrated aquaculture. This type of farming provides great effectiveness in resource utilization, as waste or by-product from one system is efficiently used, by maximizing the food production in the same area. The integrated aquaculture has the benefit of resource utilization, reduce risk by diversifying crop, and provide additional income and food for the small-scale household.

Basic concept of integrated aquaculture

Primary producers play important role in this system, they trap solar energy and convert it into organic material. Phytoplankton considered as a primary producer. Phytoplankton ate by primary consumers (zooplankton), by this way food chain begins. The energy flow is from one trophic level to another by the food chain. The waste from agriculture or livestock-based production system directly utilized by primary producers as a manure. The by-products from agriculture crop are used as feed as well as manure by the aquatic organisms living in the system. Agriculture or livestock manure when used in a pond stocked with fish, works in food web in various pathways as food, the source of minerals for autotrophs and organic matter consumed directly by fishes or zooplankton. Waste available from livestock or agriculture is used to improve soil-water fertility. These are used to increase various essential nutrients like nitrogen, phosphorus, and potash.

Suitable fish species for aquaculture

In traditional cultural practices of integrated aquaculture six species of carps catla, rohu, mrigal, silver carp, grass carp and common carp have been practiced by several workers. By looking at the success of this six species combination concept of multi-species is developed. Various minor carps (*Labeo calbasu, L.gonius, L.fimbriatus*) are identified as suitable species for integrated fish farming polyculture system. Carps species are also introduced under the mixed system with freshwater prawn (*Macrobranchium rosenbergii*) or catfishes like magur (*Clarius batrachus*), singhi (*Heteropneustes fossillis*) and murrels (*Channa marulius*, *Channa punctatus*, and *Channa striatus*) with the suitable ratio for optimal uses of available organic resources.

Types of integrated aquaculture systems

There are basically two types of integrated aquaculture systems followed by farmers in India.The agri-aquaculture system includes paddy-fish, mushroom-fish, horticulture-fish system with major emphasis on fish culture.The livestock-fish system includes cattle-fish,pig-fish,poultry-fish,duck-fish with main focused on increasing farm productivity.This system is considered as the innovation for judicious recycling of nutrient linkages contributing to farming intensification, proper use of bioresources, optimum production of protein, agricultural diversification and environmental sustainability.

Agri-aquaculture based system

(1) Paddy-fish system:

Rice is the major food source for half of the world's population. More than 90% rice produced in Asia is the main source of nutrition for rural farmers. Collection of wild fish from rice field for food in the small family is an old practice. In India fish in rice fields for culture is practiced about 1500 years ago. Proper planning of rice-fish system ensures higher productivity, increase in farm income. In a paddy-fish integrated system, rice fields normally retain water for 3-8 months in a year. It provides an opportunity to grow fish and provide off-season occupation for the farmer with additional income. Fishponds receive the crop residue as pond input. The ecological benefits of this system are weed control, pest control. Green vegetables on pond dyke, crops such as banana and papaya provide a net income of about ₹ 35,000-40,000/ha/year higher than that of rice cultivation.

(2) Horticulture-fish system:

Fruits and vegetables are rich in nutritive value contain carbohydrates, fats, proteins, vitamins, and minerals. Vegetables and fruits are usually grown on the pond dyke to utilize the areas under cultivation. The dykes of the pond are generally used for growing horticulture plants as flowers, agro-forestry, oil crops etc. Pond water is used for irrigation to the crop and nutritive silt is used as base manure. The success of this system depends on the selection of plants. The plants used in this system should be of dwarf variety, less shady, evergreen and seasonal. Dwarf varieties of mango, banana, papaya, and citrus are suitable, as they do not obstruct sunlight to the pond. Seasonal vegetables like brinjal, tomato, cucumber, lady finger, watermelon, raddish, turnip, carrot, cauliflower are grown for better profit. Flowers like rose, jasmine, marigold provides additional income to the farmers. Residues of vegetables are recycled into fishponds and grass carp at stocking density 5,000/ha has resulted in 3,500-5,000 kg/ha production. This system not only provides 20-25% higher returns compared to aquaculture alone but also engage farmer round the year.

(3) Aquatic weed-fish system:

In this integration system, various types of aquatic plants are used as feed mainly for herbivorous fishes. Herbivorous fish like grass carp directly consumes various duckweed like Lemna, Wolfia, Spirodela and water fern Azolla. These floating plants have higher proteins, low fat, fibre, and low cellulose. These plants have good digestibility for livestock and fish available throughout India. The duckweed is consumed by grass carp and excreta from the fish is used as fertilizer for the pond. Azolla is a nitrogenous biofertilizer in fish

ponds produce nitrogen, phosphorus, and potassium by trapping the solar energy. Use of Azolla as a feed ingredient is of special importance in aquaculture system because it has high protein content (13-30%). Spirulina (blue-green algae) also known as "wonder gift of nature" used as incorporated diets shows higher growth and play an important role in pigmentation of ornamental fishes.

Animal husbandry-fish based system

(1) Cattle-fish system:

In this integration system, use of raw cow manure is one of the major practices all over the world. Cow dung is most commonly used manure in rural India. A cow weighing about 400-450 kg excretes about 400-500 kg of dung and 3,500-4,000 litres of urine annually. Cow dung has high sinking ability, the nutrients available are responsible for the increase in natural food organisms and also detritus and beneficial bacteria for decomposition in fishponds. Non-digested feed of cow dung is directly consumed by fish. Biological oxygen demand of cow dung is very low because it is already decomposed by microorganisms in the ruminant. The excreta is highly beneficial for filter feeding and omnivorous fish such as catla and silver carp. A group of 5-6 cows can provide an adequate quantity of dung and urine to produce 3000-4000 kg fish/ha/year. This system provides 9,000 litres of milk/year. The fresh cow dung and urine collected separately can be applied periodically @ 10 tonnes/ha/year to culture ponds.

(2) Pig-fish system:

This integration system is far better compared to other integration systems as it provides both meat and fish at a low cost. A space of about 3-4 m^2 is required for a pig of about 70-90 kg. Popular suitable pig species used by farmers are White Yorkshire and Hampshire. The excreta from the pig is utilized for fertilizing the pond which is directly put in the pond or partially decomposed before application in ponds. Mainly in rural India farmers used agro-industrial waste like press mud, poultry droppings and vegetable waste like rotten potatoes, tomatoes, pumpkin etc. mixed with pig feed (maize, groundnut, wheat bran).A fully matured pig provides an adequate quantity of dung i.e500 to 600 kg/year and excreta of 40-45 pigs provides an adequate quantity of manure to fertilize 1 ha pond. Application of pig dung increases the nutrient quantity in the pond which enhances phytoplankton and zooplankton. A harvest of about 3-4 tonnes/ha results from the pond in 12 months without any feed and fertilization at a stocking density of 8,000-8,500 fingerlings/ha.

(3) Poultry-fish system:

In this integration system, poultry droppings are used as fertilizer in fishpond as a source of production of fish. This system requires better management, experience and ability of farmers to get better economics. The management practices include good quality of chicks, housing, feeder, water trays and control of diseases. In the poultry-fish system, birds have to be housed in three types of system i.e intensive, semi-intensive and extensive system. The house of the birds is built on the pond dyke or inside the pond. In this system, each bird requires 0.3-0.4 m^2 space. The floor is covered with litter prepared with chopped straw, dry leaves or groundnut shells. Selection of reared birds depends on meat quality, egg type and suitability with fish. Egg production and weight gain are important criteria for selection of birds. Poultry feeds are available in various forms for

every stage of birds. Birds are generally fed with starter feed 0-8 weeks, grower 8-20 weeks and brooder feed 20 weeks onward. Use of clean water for drinking and hygienic condition in the poultry house is most important for the better economy. Marketing of birds starts after 5-6 weeks of rearing when it attains a weight of about 1.2-1.5 kg. Poultry waste such as leftover feed, droppings and litter is used for increasing biological productivity of pond water. One adult chicken produces about 25-30 kg of excreta/year to provide sufficient manure. In 1 ha water bodies 1,000 birds produce adequate manure with 90,000-100,000 eggs and 1,500 kg meat/year.

(4) Duck-fish system:

This type of integration system is very common in countries like China, Hungary, Germany, Poland and some Indian states like Andhra Pradesh, Odisha, West Bengal, Bihar, Kerala, Tamilnadu and North-East states like Assam, Manipur, Tripura etc. This system is very beneficial for the farmer as it provides both meat as well as eggs. In the pond, ducks roam freely during daytime and feed on several aquatic animals and plants. Waste from duck used as nutrient source provides carbon, nitrogen and phosphorus for the production of natural food organism used by fish. In duck-fish integration system ducks feed upon juvenile frogs, snails, dragonfly and tadpoles. The excreta goes directly to the ponds containing essential nutrients, nitrogen and phosphorus increasing production of natural fish food organisms. House of duck should have good ventilation, space area, laying boxes, egg trays for the collection of eggs. In this system, houses are built in the middle of the ponds or on the pond dykes. Stocking of fish fry of size 1.5-2.0 inch with one-day-old ducklings is most suitable for better economy. The duck starts laying eggs after 6 months of age and it continues for 2-3 years depending upon species, nutrition and environment. In the multi-species culture of fishes, 3,000-4,000 kg/ha/year fish is expected from this system in addition to 4,000-6,000 eggs and 500-750 kg of duck meat. The income generated from eggs and meat covers the rearing and feed cost of duck and money obtained from fish sale becomes profit.

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FIRST BIO-FORTIFIED POMEGRANATE HYBRID – SOLAPUR LAL

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Pomegranate (*Punica granatum* L.) is native from Iran to the Himalayas in northern India and has been cultivated since ancient times throughout the Mediterranean region of Asia, Africa and Europe. Pomegranate is an important fruit crop of arid and semiarid regions of the world. India is one of the leading producers of pomegranate in the world with around 50% share globally. In India, it is cultivated over 2.62 lakh hectares with an annual production of 30.34 lakh tonnes and average productivity of 11.58 tonnes per hectare. Maharashtra is leading producer of pomegranate followed by Karnataka, Gujrat and Andhra Pradesh. In recent past, pomegranate cultivation has been gaining momentum in Rajasthan, Orissa, Chhattisgarh, Uttarakhand, Madhya Pradesh, Himachal Pradesh, Tamil Nadu and Uttar Pradesh.

Pomegranate is high value crop and also called as dollar crop. Entire tree of pomegranate is of great economic importance. Apart from its demand for fresh fruits and juice, the processed products like pomegranate wine, pomegranate tea and candy is also gaining importance in world trade. Demand in international market has widened the scope for earning higher dividends from this crop.

It is an ideal crop for sustainability of small holdings because of its adaptability to topography, soil and agro-climatic conditions prevailing in arid and semi-arid regions of India. The history of commercial cultivation of pomegranate in India started in 1936 with identification of cultivated variety of pomegranate by Dr. G. S. Cheema at Fruit Research Station, Ganeshkhind, Pune which was later named as Ganesh in 1970. This was the first popular commercial cultivar of pomegranate for extensive cultivation. In 2003, Mahatma Phule Krishi Vidyapeeth, Rahuri, Maharashtra released Phule Bhagwa pomegranate variety through selection from Ganesh variety. It is popularly known as Bhagwa. This variety became highly popular over traditional cultivar. Ganesh having pink coloured arils. Bhagwa is soft seeded variety with bright red rind and aril colour. Bhagwa has high market and export potential and more than 80% area in India comes under this variety. The popularity of pomegranate cultivation can be witnessed through tremendous increase in pomegranate area under cultivation, production, productivity and export as compared to those of 2003-04.

Due to rapid increase in pomegranate area, the pomegranate industry started hurdles due to diseases and insect pests. During 2001 to 2004, pomegranate production has been impeded due to diseases like bacterial blight and wilt because of monoculturing with susceptible variety Bhagwa on large area, congenial weather conditions, absence of satisfactory chemical control

measures for bacterial blight, lack of understanding of its mode of propagation and spread has resulted in spread of disease to newer areas causing heavy losses to the growers.

National Research Centre on Pomegranate was established at Solapur, Maharashtra in 2005 by Indian Council of Agricultural Research (ICAR), New Delhi to augment the production, productivity and utilization of pomegranate through basic strategies and applied research. ICAR-NRCP addressed pomegranate cultivation hurdles and started the strategic research on pomegranate. Pomegranate improvement programme is highly dependent on exploring the variability of characters existing in germplasm, therefore, NRCP have a well established field gene bank of pomegranate with 362 indigenous and exotic germplasm lines which serve collection of genes for diverse characters like BBD tolerance, high yielding, nutritionally rich and cracking resistance.

Keeping in mind, the important role of pomegranate in horticulture, not only as a super health fruit, but also in doubling farmers income in arid and semiarid areas that face challenges of water scarcity, climate change and small land holdings. NRCP released first biofortified, high yielding pomegranate hybrid “Solapur Lal” in 2017. A promising hybrid of pomegranate Solapur Lal (NRCP H-6) has been developed through breeding by crossing of Bhagwa with (Ganesh x Nana) x Daru. For hybridization, commercial traditional Bhagwa variety was used as female parent and wild cultivar like Nana and Daru were used as male parent.

Solapur Lal (NRCP H-6) hybrid Characteristics:

Solapur Lal is first biofortified high yielding pomegranate hybrid. This hybrid fruit contains higher iron, zinc, ascorbic acid and anthocyanin than ruling Bhagwa variety. Biofortification is process of increasing the micronutrient content and nutritive value of crop through selective breeding and genetic modification. In the world, 60% population are iron deficient and 30% population deficient in zinc, therefore, this hybrid will be a boon for overcoming nutrient deficiencies in humans.

The Solapur Lal hybrid matures earlier than the prevalent Bhagwa variety, so production cost can be reduced as compared to Bhagwa and at the same time, this hybrid is more productive than Bhagwa. Demand for export is expected as Solapur Lal is more nutritious and fruit are attractive than Bhagwa. Fruits of Solapur Lal variety are medium in size and fruit and arils are attractive and dark red in colour. Seed texture of this variety is medium. TSS and 100 seed weight of this hybrid is more than Bhagwa variety. The keeping quality of fruits is high due to its higher rind thickness. This hybrid will be very important for increase in production because in this hybrid, flowering and fruit setting is higher than other varieties. Many farmers are of the opinion that the Solapur lal hybrid is less susceptible to bacterial blight and other diseases than prevalent Bhagwa variety.

Due to its high productivity, Solapur lal hybrid has become popular among farmers in short time span. This variety is in great demand from Maharashtra as well as the pomegranate producing states in the country. More than 10 Lakh Solapur lal plant saplings have been successfully planted in the country through the nursery provided by National Research Centre on pomegranate. As Solapur lal is hybrid, it is more responsive to fertilizers. This variety yields more and size of fruit is found large at 150% of the recommended fertilizer dose application.

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Comparison between Solapur Lal and Bhagwa :

Solapur Lal

Bhagwa

Sr. No.	Characteristics of Solapur Lal (NRCP H-6)	
1.	Tree Height (m)	2.0 to 2.3
2.	Fruit Maturity (Days)	160-165 Days (15-25 days earlier than Bhagwa)
3.	No. of Fruits/ Plant	130 to 140 (Higher than Bhagwa)
4.	Fruit Yield (kg/Plant)	35 to 39 (Higher than Bhagwa)
4.	Fruit Yield (t/ha)	23 to 27 (Higher than Bhagwa)
5.	TSS (Brix)	17.5 to 17.7 (Higher than Bhagwa)
6.	Fruit colour	Dark red
7.	Aril colour and Size	Bold with Dark red colour
8.	Rind thickness (mm)	3.3 to 3.5
9.	Fruit size	Medium
10.	100 Aril weight (g)	40 to 42 (Higher than Bhagwa)
11.	100 g Aril juice content (ml)	45 to 50 (Higher than Bhagwa)
12.	Vitamin-C (mg/100g)	19.4 to 19.8 (Higher than Bhagwa)
13.	Anthocyanin (mg/100g)	385 to 395 (Higher than Bhagwa)
14.	Iron (mg/100g)	5.6 to 6.1 (Higher than Bhagwa)
15.	Zinc (mg/100g)	0.64 to 0.69 (Higher than Bhagwa)
16.	Purpose	Table purpose and suitable for processing

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IMPORTANCE OF STORED GRAIN INSECTS PEST AND THEIR MANAGEMENT

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Economic importance of stored grain pest

Out of the total production, about 70% is retained and stored by farmers for future consumption and stored for seed purpose and only 30% is marketable during the current season. Insects alone are responsible for enormous spoilage in storage as they feed on grains, bore the kernel and destroy the germ portion, cause heating and deterioration. If not the problem of storage is solved satisfactorily the losses due to storage by insects continuous all the years and leads to shortage of produce and has remained an issue of utmost concern. Insects damage the stored products both in terms of quality and quantity which may account for 20–30% in the tropical zone and 5–10% in the temperate zone. The effective control and management of pests in storage has been the long goal of many entomologists throughout the world. 10% of post-harvest losses are due to instinctive storage, insects, rodents, micro-organisms etc of which insects alone are responsible for 2 to 4.2 percent. Nearly 600 species of insects were found to be associated with stored products of which 100 species were found causing economic losses. The main loss caused by stored insect pests is not always due to consumption but the extent of contamination they have made with their waste, caste skins, webbings, and other body parts. Different species of insects are found in the godowns, of which only a few of them cause direct damage to products. Most insects feed only on damaged or processed grains and their existence results in contamination of the products. Around fifty species of insects are of economic concern belonging to the orders mostly Lepidoptera and Coleoptera which causes weight loss, nutritional loss, and viability loss and encourage microbial growth on damaged products which minimize the storage period.

Source of Infestation

Insects from fields along with the produce enter in to the godowns and lay eggs on the matured grains. The eggs hatched to larvae under favorable conditions and can crawl/fly to fresh stocks and infest them. Generally farmers use empty gunny bags or boxes without proper disinfection for the next season. Whenever the seeds or grains are filled in such bags, infestation appears. Larvae remain hidden at the joints or corners of the carriers/boxes, migrate to the food grain lots and cause losses. Stored products should be monitored least once in a month from November to April or at least twice per month during from May to October as the rate of multiplication of the insects is more during these days due to the favorable conditions.

Management

A. Preventive measures

Cleaning the storage structures, sealing of cracks, crevices and holes present in the floors, roofs and on side walls. Whitewash the Sheller before their use. Storage structures/godowns/gunny bags should be disinfected with approved residual insecticides preferably with Malathion 50% EC,

with dilution 1: 100. Good hygienic conditions and proper sanitation of the storage bags and boxes avoids insect damage during storage. Polyester- polythene 400 gauge lined canvas was found to be resistant to all types of insect attack. Improved storage structures namely aluminum bin, Pusa bin, Pusa cubicle PAU bin, IGSI domestic bin are well suited for storage in long terms. If the storage products are meant for seed purpose, mix them with activated Kaolin or Lindane 1.3 D or Malathion 5 D at 1 kg for every 100 kg of produce and then fill in gunny bags or polythene lined bags or boxes for storage. If the produce is meant for grain purpose, mix it with 1 kg of activated kaolin or mix 1 kg of neem seed kernel powder or neem leaf powder for every 100 kg of grain.

B. Curative measures

The infestation of stored grain insect pests can be minimized in different ways such as Physical, Mechanical, Ecological and Chemical control.

1. Physical control measures

Agricultural produce need to be dried to safe moisture level prior to storage as crops are generally harvested at high moisture content to avoid shattering losses. Natural sun drying can be done on cemented platforms, mats, jute cloths or on metal sheets. Heat treatment of stored grain at 55°-60° C. Mixing of inert dusts like ash to grain makes difficulty for insects to enter in to the storage structures.

2. Mechanical control measures

These measures are practicable and include sieving of grains and drying the grains in heaters before storage. Making disturbance in the bags or boxes can also destroy the insects to some extent. Screening of grains through sieve helps in separation of free living insects and such insects have to be destroyed by killing. Before filling the grains, stitch up all torn out bags and avoid the bags and boxes with holes for storage purpose.

3. Ecological control measures

During storage, pest can be well managed by decreasing O_2 concentration or increasing CO_2 or N_2 concentration in the atmosphere thus interfering with the normal physical and biological process of insects. This can be achieved with airtight storage, modified atmospheric storage and controlled atmospheric storage. Temperature, humidity and moisture content of grain and availability of oxygen and carbon dioxide levels have to be properly managed by designing and constructing the storage structures which create unfavorable conditions for insect attack as grains with less than 10% moisture are not suitable for multiplication and survival of most of the insects. Food grains should be kept in airtight sealed structure like Pusa bin.

4. Chemical control measures

Fumigation is the most excellent process intended for managing stored insects but the process of fumigation should be carried out only under supervision of experts with proper carefulness. In our country, Aluminum Phosphide (phosphine gas - restricted use), EDB and EDCT have been recommended for fumigation of food grains. The fumigants should be handled with great care only by well trained experts. For cover fumigation use 3Aluminium phosphide tablets each of 3 g per tonne of grain and for shed fumigation use 21 tablets of 3 g each for 28 cubic metres and cover the bags immediately for five days. The insecticidal treatment is to prevent the insect cross infestation and insecticides should not be sprayed directly on food grains. Mixing of insecticides

with food grains for consumption is not recommended. However they can be mixed with grains using for seed purpose only. Usually pyrethrum dust is used as seed protectant before storage of the grains. The insecticides recommended for stored grain are Malathion 50 E C at 0.5%, Pxrimiphos methyl 50% EC at 0.5%.

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MULCHING IN HORTICULTURE

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A mulch is a coating of material that is put to the soil's surface. Mulch is used for a number of reasons, including preserving soil moisture, boosting soil fertility and health, limiting weed development, and improving the aesthetic attractiveness of the region.

Types of Mulch

Mulch can be separated into two main categories:

Organic – This form of mulch is manufactured from natural materials that decay over time and must be replaced on a regular basis. They are a favourite among most gardeners because they may improve the fertility, aeration, and drainage of the soil as they decompose.

Inorganic – These mulches do not decompose quickly and do not improve the soil's quality. While inorganic mulches like gravel are most commonly used to suppress weeds, they may also offer a beautiful aspect to your landscape and aid to warm the soil for early planting by retaining heat.

Organic mulch

These mulches are beneficial to farmers because they decompose into manure and boost soil fertility. Leaves, sawdust, wood chips, trimmed bark portions, coconut coir, gunny bags, jute bags, kitchen trash, newspaper, cardboard, Peat moss, animal waste, grass clippings, dried leaves, Garden waste, farmyard manure, and so on are all examples of organic mulches.

Inorganic mulches

These mulches have no soil-enhancing qualities (adding fertilizers). Inorganic mulches are usually made of plastic.

Plastic mulches-Polyethylene is a popular mulch because it absorbs long-wave radiation and raises the temperature surrounding plants at night. Slits or perforations in thin plastic sheets allow crops to grow. This technology is mostly utilised for large-scale vegetable production. They suppress weeds, minimise dryness, and reduce nutrient loss through leaching, among other things.

Annuals- 20 to 25 Micron thickness
Biennials - 40 to 50 Micron thickness
Perennials – 50- 100 Micron thickness

There are different types of plastic mulches, black, transparent. Now a days red, grey and other coloured mulched are also used.

Gravel, Pebbles, and Crushed stones: These materials are used in dry land fruit crops. 3-4 cm of stone or rock layer helps in weed control and facilitates the infiltration of rainwater into the soil. But they reflect the solar radiation leading to a hot soil environment during summers.

Benefits of mulching

Retains soil moisture- The rate of evaporation is lowered as a result of mulching. As a result, watering at irregular intervals is not necessary. This helps to keep the soil wet, avoiding the soil from drying up and conserving water.

Control weeds- Mulch blocks sunlight from penetrating the soil, inhibiting the development of weeds.

Increase soil nutrition- Depending on the type of mulch employed, mulching can increase, reduce, or have no effect on soil nutrition. Organic mulch with a higher nitrogen concentration increases production while also improving soil quality. Sawdust, straw, and bark are a few other organic mulches that might help with soil fertility.

Control soil erosion- Mulch acts as a barrier between the soil and the wind and water. As a result, they are not in direct touch with the soil, and the dirt is not blown or washed away.

Mulching also help to regulates soil temperature, water conservation, prevent leaching of fertilizer, reduce pesticide use and prevent spread of disease and pest,

Disadvantages of mulching

Few mulching materials like plastic films are costly and not affordable by everyone.

Readily not available-Some mulching materials like compost, manure are not always available. It create nitrogen deficiency, sometimes organic mulches may keep the soil too moist. This restricts oxygen in the root zone, where the soils have a poor drainage system.

Best time for mulching

The end of the rainy season is the ideal time for mulching.

How does mulch work?

The mulch that is put over the soil stops direct sunlight from penetrating the soil and reduces evaporation. As a result, there is less of a need to irrigate the crop on a continuous basis. Weeds require a lot of sunlight in order to grow. Mulching, on the other hand, absorbs sunlight, preventing weed growth. It reduces soil erosion by preventing rain from directly gushing into the soil. The organic mulch decomposes, releasing nutrients into the soil and providing food for microbes, which protects the soil's healthy microorganisms.

Conclusion

Finally, mulches increase the aesthetic value of landscapes and the economic worth of crops by preserving soil moisture, improving soil nutrients, controlling erosion losses, suppressing weeds in crop plants, and removing the residual effects of pesticides, fertilisers, and heavy metals.

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WHITE GRUBS (SCARABAEIDAE: COLEOPTERA) : SERIOUS POLYPHAGOUS PESTS IN THE DESERTS OF INDIA

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Highlights

- White grubs are the major insect pests prevailing in the deserts of India.
- They infest *Kharif* crops and can cause loss up to 80 percent.
- Adults during June-July and grubs during July-August can be effectively managed by integration of multiple control methods.

Introduction

Adults are known as chafers or May/June beetles because of coincidence of their emergence during the month of May/June. They are dull brown with light brown abdomen and dark brown legs and feed on leaves of plants such as neem, *Acacia*, ber, *Prosopis*, drumstick etc. The larvae are known as white grubs or root grubs. They are soft bodied, fleshy creamy or dingy white in colour with brown head and body remains curved like an incomplete arc in the form of letter 'C'. During the rainy season (*Kharif*), they feed on underground roots and stems of all crops grown such as groundnut, pearl millet, sorghum, maize, pulses, vegetables etc.

Predominant species of white grub in the deserts of India

1. *Holotrichia consanguinea*, *H. serrata* and *H. insularis*
2. *Anomala bengalensis*
3. *Maladera insanabilis*
4. *Rhinyptia meridionalis* and *R. laeviceps*

Life cycle of *Holotrichia* spp.

Holotrichia spp. are the most widely destructive species of white grubs in the Indian Sub-continent. The beetles emerge from soil at dusk after a good shower of rain. The mating takes place on the host trees and lasts for about 9-16 minutes. The mated females return to the soil and lay 10 to 40 eggs at a depth of 5-15 cm in most soil. The pre-ovipositional period varies from 2-5 days. The eggs are oval, creamy white. The incubation period varies from 7 to 10 days. The grubs continue feed on roots from July to mid - October. The fully grown grubs make earthen cell and pupate in the beginning of November. The pupae become adults in 2-3 weeks. The adults hibernate in soil in the pupal cell till the next monsoon shower. There is only one generation in a year.

Damage and loss

The grubs feed underground on the roots of host plants, while the adults on the foliage of plants in the vicinity during the night. The losses caused to the various crops range between 40 and 80 per cent in endemic areas.

Management

An effective management strategy has been formulated for both the damaging stages *i.e*. adult beetles and grubs.

Adult

In month of April-May, deep ploughing of fallow land is quite effective to expose hibernating adults. Light traps coinciding with onset of rains starting from second week of May to 1st fortnight of July are quite effective during peak emergence period. Adults can be manually collected during the night hours from most preferred hosts. One tree within a radius of 15m can be sprayed with insecticides (Imidacloprid 17.8 SL @ 0.027% or monocrotophos @ 0.05% or carbaryl 0.2%) and loaded with pheromone dispersers (3/tree).

Grub

Deep ploughing in the month of August-September to expose the 3rd instar grubs to predatory birds is effective in reducing the grub population. Sowing of tolerant crops like amaranthus, soybean and maize in endemic pockets is recommended which are less susceptible to grub in comparison to millets. Application of well decomposed FYM in the field is also effective to some extent in killing the 1st instar grubs as the newly hatched grubs can serve partly on decomposed organic matter.

Seed treatment can be done with imidacloprid 17.8 SL @ 3 ml/kg seed or clothianidine 50 WDG @ 2 g/kg seed, imidacloprid 600 FS @ 6.5 ml/kg seed in case of groundnut. Chemigation (application of any chemical with irrigation) can be done with imidacloprid 17.8 SL @ 300 ml/ha or quinalphos 25 EC at 4 l/ha in standing crop after 21 days of adult emergence. In rainfed crops, insecticidal mixed soil can be applied just before the possibility of rain. Application of phorate 10 G @ 25 kg/ha during 1st week of July with intercultural operations where moisture stress conditions prevail is effective.

For organic farming, biological control agents such as fungi (*Metarhizium anisopliae* and *Beauvaria bassiana*), nematodes (*Setainernema glaseri*, *Heterorhabditis* spp.) and botanicals such as calotropis leaf extract in cow urine (1:1) @ 5 l/ha can be used effectively.

Conclusion

The present article deals with important aspects about white grub which will reinforce the basics about this insect. New control measures given in this article for adults and larvae will provide useful information to farmers for the management of this havoc insect in Rajasthan.

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